A LABORATORY STUDY OF INSULATION OF CONCRETE BRIDGE DECKS

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by

D. L. YODER

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

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TO: K. B. Woods, Director
Joint Highway Research Project

September 18, 1964

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 7-4-9
Project: C-36-56I

The Final Report on the research project titled Bridge Deck Insulation is attached. This report "A Laboratory Study of Insulation of Concrete Bridge Decks" has been prepared by Mr. D. L. Yoder, Graduate Assistant on our staff under the direction of Professor W. L. Dolch.

The research reported here concludes the research on this project even though the original proposal contemplated including further research, including a field study on the total project. The laboratory results together with other information resulted in the recommendation from the study that a field investigation was not warranted.

This research project was performed as a cooperative research study using HPS funds in part. As such this report will be submitted to the Indiana State Highway Commission and to the Bureau of Public Roads for their review and comments.

Respectfully submitted,

Harold L. Michael

Harold L. Michael, Secretary

HLM:bc

Attachment

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Final Report

A LABORATORY STUDY OF INSULATION OF CONCRETE BRIDGE DECKS

by

D. L. Yoder
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Joint Highway Research Project

Project: C-36-56I

File: 7-4-9

Prepared as Part of an Investigation

Conducted by

Joint Highway Research Project
Engineering Experiment Station
Purdue University

in cooperation with

Indiana State Highway Commission

and the

Bureau of Public Roads
U. S. Department of Commerce

Not Released for Publication Subject to Change	Not Reviewed By Indiana State Highway Commission or the Bureau of Public Roads

Purdue University
Lafayette, Indiana
September 18, 1964

Acknowledgment

This work was performed in the laboratories of the Joint Highway Research Project of Purdue University. It was financed by a research grant from the Indiana State Highway Department and the Bureau of Public Roads, U. S. Department of Commerce. This support is gratefully acknowledged.

Professor K. B. Woods, Head of the School of Civil Engineering, Purdue University has been interested in the problem of bridge-deck icing for many years. His encouragement of this study is greatly appreciated.

The work was performed under the direction of Dr. W. L. Dolch.

INTRODUCTION

Statement of the Problem

Under certain moisture and temperature conditions, ice forms on the surface of a bridge deck before it forms on the adjacent pavement. This freezing creates a serious hazard to the motorist who, accustomed to an ice-free pavement, suddenly finds himself on a bridge deck covered with a glaze of ice.

Several methods have been tried to prevent this problem. These include heating coils and cables, bridge deck insulation, and chemical de-icers. By far the most common of these methods is the use of salts, which although effective, frequently results in increased deterioration of the bridge deck concrete.

Since the bridge deck freezes more rapidly than the approach pavement, it also undergoes more cycles of freezing and thawing, again to the detriment of the concrete.

There are two reasons for early freezing of bridge decks. First, the approach pavement receives heat from the great volume of subgrade beneath it, while the bridge deck is open to the air on the bottom. Second, owing to this subgrade, the adjacent roadway is, in effect, insulated from heat loss in that direction, and gains or loses heat only from its exposed surface. The bridge deck, meanwhile, loses its heat through both top and bottom surfaces.

Recently, much work has been done on this problem by the use of a sprayed-in-place polyurethane foam applied to the underside of the deck. The idea behind this method is that the foam acts much as does the subgrade in retarding the flow of heat from the bottom of the slab, and should therefore cause a delay in the freezing of any moisture on the top surface.

Purpose of the Investigation

The goal of this investigation has been to evaluate in the laboratory the effects of insulating the underside of a bridge deck on the temperatures in the concrete and at its surfaces and on the process of freezing of water on the top surface.

Review of Other Work

Eleven other states are known to have conducted research on the use of urethane foam as bridge deck insulation. These are: Colorado, Illinois, Kentucky, Michigan, Missouri, New Jersey, New York, Ohio, Vermont, West Virginia and Wisconsin.

The first published report on the effectiveness of a field installation was in Highway Research Abstracts, in 1961, in an article by H. B. Britton entitled "Urethane Foam Insulation for Bridge Decks" (1).* In this article Britton states, on the basis of several visual observations and thermocouple readings from the mid-depth of the slab, that "Results indicate benefits in safety, reduction in number of de-icing chemical applications, and reduction in number of freeze-thaw cycles."

In Colorado, after a year of visual observation of a partially-insulated bridge deck near Pueblo, the opinion was expressed that little or nothing was accomplished (2).

After almost three winters of observations of a ten-thousand square foot installation of urethane foam on the underside of a bridge deck, the Illinois State Toll Highway Commission reported that they have come to no conclusion concerning the value of underside insulation of bridge decks (3).

In Missouri, Axon and Couch (4) reported that, "Data are considered insufficient to establish the merit of the insulation, but indicate that the effects tend to be beneficial."

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* Numbers in parenthesis refer to entries in list of references.

The general conclusion drawn from Ohio State's preliminary studies (5, 6) on the effect of insulating a bridge deck with urethane foam and similarly treating 4 x 4-ft. slabs with various insulators was that the beneficial effects of insulating the underside of bridge decks have been established. Their tests are continuing. Tests on an insulated bridge in Wisconsin (7) led to the conclusion that the initial results of the experiment indicated little benefit was derived from the insulation.

West Virginia investigators (8) concluded that the method appears to be an expensive means of partially solving the problems presented by early bridge-icing. Owing to the small number of freeze cycles, the project is being extended in order fully to assess the existing field installation.

Vermont (9) reported that general trends of their experiments concur with results obtained from similar experiments in other states. It was mentioned that the occurrence of conditions conducive to bridge icing (i.e. water on the deck during a temperature drop to below freezing) occurred only 0.7% of the time. Their results also showed that the effects of the insulation were erratic, with the desired effect occurring 32.5% of the time and a "reverse" effect where the insulated portion froze before the uninsulated occurring 67.5% of the time on one bridge.

Despite the number of tests conducted, results appear to be inconclusive. With the exception of Ohio State's slabs tested outdoors, all the work done has been on field installations of the insulation on bridge decks. Because of this method of testing, many experimental errors may be introduced. These can include variable thickness of the bridge slab,

variable thickness of the sprayed-in-place foam, variable amounts of moisture on the insulated and control spans, variable traffic, which would tend to break up ice formation, variable atmospheric conditions (e.g. wind eddys) and instrumental errors due to difficulties in placing thermocouples properly in existing slabs and also due to long leads from the thermocouples to the recorder.

Reported conclusions vary from stating that the insulation is beneficial to remarking that no benefit was derived from the insulation. All conclusions tend to be general because the data are inconclusive. However, from all reports an average conclusion could be drawn that the effects of the insulation are small, yet probably beneficial, and that insulation is an expensive means of, at best, only partially solving the problem.

Approach to the Problem

It was felt that an inexpensive laboratory investigation of bridge deck insulation would yield more meaningful results than a more elaborate field installation. Using the laboratory results, a basis could then be found for specifying the experimental factors for a complete field installation, which would follow if justified by laboratory results.

Proposed Approach

It was proposed to develop a method for the evaluation of insulation on the underside of a bridge deck by the testing of small slabs.

A 12 x 12-in. slab was selected as being of convenient size to handle, and also, if properly insulated on the edges, to provide the one-dimensional heat flow desired.

To construct this slab, a mold for the concrete could be made using 4-in. thick Styrofoam as the sides, and with the insulation being tested as the bottom. Thermocouples could then be placed in the mold so that they were in the proper position in the finished slab.

Using a walk-in cold room, ambient temperatures around the slabs could be dropped by varying amounts after the slabs had attained an initial equilibrium temperature. Then, using a recording potentiometer, slab and air temperatures could be recorded for later analysis.

EXPERIMENTAL WORK

Concrete

Cement used was ASTM Type I portland from the local market. The coarse aggregate was a local gravel of 3/4-in. maximum size. Fine aggregate was sand with a fineness modulus of about 2.95. The air-entraining agent used was Darex AEA.

Insulation

Five insulating materials were used. They were polyurethane foam, expanded polystyrene foam, lightweight vermiculite insulating concrete, regular-weight concrete, and a thin layer of air trapped by a plastic film.

The polyurethane foam was obtained from the Dow Chemical Company under the trade name of Thurane. Three different thicknesses were used - 3/4 in., 1 in., and 1 1/2 in. The coefficients of thermal conductivity for each thickness at both 30 F and 70 F are given in Table 1. The unit weight and advertised K factor for each are also given. The measured values were reported by the company. The trade name of the expanded polystyrene foam is Styrofoam, and it was obtained from the manufacturer, The Dow Chemical Company. The 1" thick Styrofoam used is designated CB (Construction Board) and is the low density form. For the insulation around the edges of the slab, 4" thick Styrofoam CB was used. The coefficients of thermal conductivity for the 1" material at 30 F and 70 F are given in Table 1. The unit weight and advertised K factor are also given.

For making the lightweight concrete, vermiculite aggregate was obtained under the trade name of Zonolite. The dry unit weight was 9.8 pounds per cubic foot. The cement used in making the vermiculite concrete

TABLE 1

PHYSICAL PROPERTIES OF INSULATING MATERIALS

Material	Thermal Conductivity, BTU in./hr. ft.^{2} F			Unit Weight, lb./ft.^{3}
	30 F	70 F	Advertised	
3/4" Urethane Foam	0.16	0.16	0.16 - 0.17	2.1
1" Urethane Foam	0.14	0.14	0.16 - 0.17	2.0
1 1/2 " Urethane Foam	0.14	0.14	0.16 - 0.17	1.8
1" Styrofoam	0.23	0.24	0.23 - 0.25	2.0

was the same as that used for the regular-weight concrete. The air-entraining agent was Vinsol resin.

The regular-weight concrete used as an insulator was merely an additional 1" depth of slab that was cast integrally with the test specimen.

In the experiment where air was trapped under the slab, a 4-mil thick polyethylene film (Visqueen) was used and the air was trapped between the plastic film and the bottom surface of the slab.

Slab Preparation

During the course of the study, two different sets of slabs were used. These are designated Type I and Type II. The Type I, or first, slabs were prepared and cast not at the same time, since they were for essentially exploratory runs. There were three thermocouples in these slabs - one at the top surface, one at the bottom surface, and one at mid-depth.

The forms were made of 4" thick Styrofoam. Dimensions are shown in Figure 1.* These four sides were bonded together with a casein glue under pressure. The insulation under consideration, either Styrofoam or urethane, was cut to the size of the form bottom and a forced fit was made between the form and the insulation. Paraffin was then melted and applied into all joints of the form, and between the form and the bottom insulation. This was done so that no water from the fresh concrete could seep out and also because the glue was not waterproof. After measuring the positions for the thermocouple wires, holes were punched through the form with a knitting needle and the thermocouples were threaded through the holes and positioned so

* The figures are grouped at the end of the report, before the Appendix.

that the junction was exactly in the center (in a plan view) of the form. The places where the thermocouples emerged from the form were also paraffined to prevent escape of water. A photograph of a completed Type I form is shown in Figure 2.

In the instances where an uninsulated slab was being cast, the bottom of the form was a lightly-oiled glass plate sealed at the edges with paraffin. The entire form was then placed on a piece of 3/4" plywood to facilitate handling.

Three-fourths of a cubic foot of concrete was mixed in a tub mixer for each slab. Coarse and fine aggregates were mixed together for 1 minute, then the cement was added and mixed with the aggregate for an additional minute. Finally the water and air-entraining agent were slowly added and the concrete was mixed for two minutes. The concrete mix proportions are given in Table 2.

The concrete was placed carefully by hand into the form until it was half-filled. This concrete was then lightly vibrated using a small immersion vibrator, while taking care not to break the paraffin-insulation bond. This being done, the middle thermocouple was then laid on top of the concrete layer. The form was then carefully filled to the top with the remaining concrete. Vibrating of this lift was carried out in such a manner that the middle and top thermocouples were disturbed as little as possible. The slab was then finished with a steel trowel, carefully manipulating the top thermocouple until it was as near to the surface as possible while keeping it completely covered, both junction and wire. The slab was then covered with wet cloths and a polyethylene film. The slab was kept in this moist condition

TABLE 2

CONCRETE MIX DESIGN
FOR TYPES I AND II SLABS

Water	11.40	lb.
Cement	22.94	lb.
Coarse aggregate	54.6	lb.
Fine aggregate	54.6	lb.
Darex AEA	11.0	ml.

3" Slump
5.5% Air

for 2 days, after which it was dry-cured at room temperature (75 F) for 11 more days.

A total of 18 of these slabs were cast, as shown in Table 3.

Type II Slabs

The Type II, or second-group slabs were cast all at the same time and had other differences from the Type I slabs.

All these slabs were 6-in. thick and were made with the following amounts of insulation: 3/4-in., 1-in., and 1 1/2-in. urethane, 1-in. of lightweight concrete, and 1-in. of regular-weight concrete. An uninsulated control slab was also prepared.

The mix proportions used for the lightweight vermiculite concrete insulation are shown in Table [illegible]. The concrete was mixed at the slow speed in a Hobart N-50 mixer. First, the cement, water, and [illegible] were mixed for two minutes. Then the vermiculite aggregate was added and mixed for an additional two-minute period.

The vermiculite layer was cast to a 1-in. thickness on an [illegible] glass plate that was [illegible] paraffin. When the concrete had partially [illegible] and an aluminum foil vapor barrier were placed on the exposed surface. The [illegible] was kept in this condition for [illegible] 1/2 days until [illegible] the regular-weight concrete [illegible] layer [illegible]

[illegible]

[illegible] higher in order [illegible] by the 1/2-in. high projection of the form above the surface. Aside from this, the method of construction of the forms and installation of the insulation was the same as for the Type I slabs

TABLE 3

TYPE I SLABS CAST

SLAB THICKNESS, in.	6	7	8
INSULATION			
3/4" Urethane	X	X	X
1" Urethane	X	X	X
1½" Urethane	X	X	X
1" Styrofoam	X	X	X
4" Styrofoam	X	X	X
Uninsulated	X	X	X

TABLE 4

VERMICULITE CONCRETE MIX DESIGN

Cement	375. g.
Vermiculite	379. g.
NVR (14%)	12. ml.
Water	1040. ml.

Wet density 37.2 lb./cu. ft.

Thermocouples were spaced at one-inch intervals inside the slab, plus one each on the top surface and on the bottom surface of the concrete. In order to assure correct spacing, a notched mortar support (Figure 3) was placed in each form. This mortar insert had a water-cement ratio of 0.54 and a sand-cement ratio of 2:1. They were cast 5 days before the concrete slabs and were notched with a diamond-bladed saw on the day before the slabs were cast. The mortar support was moist up to the time that it was placed in the form. Thermocouple wires were placed through the notches on the support and run to the center of the slab. The support was positioned about 2-in. from the thermocouple junctions.

The concrete was mixed as for the Type I slabs. It was placed by hand into the forms and special care was taken around the mortar support and the thermocouple wires to avoid knocking them out of position. Each slab was cast in two lifts, each of which was carefully and briefly vibrated as was done in the Type I slabs. The top surface thermocouple was laid into the fresh concrete by hand and positioned such that it was (at the most) 1/16-in. below the top surface. The slabs were finished with a steel trowel, and about twenty minutes later damp rags and a plastic film vapor barrier were placed on them. They were kept in this moist condition for 2 days, after which they were moved to the cold room and allowed to dry at 20-25 C for 25 more days.

Temperature Measuring System

For the purposes of identification all tests but preliminary ones on Type I slabs will be designated Series I; likewise all but preliminary tests on Type II slabs will be designated Series II.

Thermocouple Wire

For Series I tests, the thermocouple wire used was Minneapolis - Honeywell 24-gauge copper-constantan wire with plastic insulation. Junctions were constructed by twisting the two wires tightly together and connecting them with a drop of solder. The joint was trimmed as small as possible in order to reduce the lag in measuring temperatures. The junctions were not protected when encased in the concrete slab.

For Series II tests, plastic insulated, 24-gauge, copper-constantan "Serv-Rite" thermocouple wire was used. Connections were the same as for Series I tests.

Terminal Board

For Series I tests, a terminal board with capacity for 8 input thermocouples was used. Two 8 terminal strips were used to provide binding posts for 8 separate thermocouples.

For Series II tests, the terminal board was altered by the addition of seven more terminal strips which provided a capacity of 36 separate thermocouples.

Wiring and Switching Arrangement

For Series I tests, thermocouple lead wire ran from the terminal board through a hole in the cold room wall and into an eight-position switch. A single ice-bath reference junction was used. For Series II tests, the 36 thermocouple lead wires were cabled and ran along the floor of the cold room, through the wall and into the switch box. This switch box had a capacity of 44 thermocouples by means of a multiple switching arrangement. The box was insulated with glass fiber, since it was found that a temperature differential between the different

switch points caused the readings to be in slight error. A single reference junction was again used.

Voltage Measuring Devices

For preliminary work in Series I tests a Leeds and Northrup Model K-2 potentiometer was used, but for all other tests, in both series, a Sargent Model SR Recording Potentiometer was used. This recorder had a 250 mm chart width and a full scale reading of one millivolt. Two chart drive motors were used, a one-inch per minute motor and a three-inch per minute motor. The zero point could be set to any position on the chart. The accuracy of this recorder is ± 20 microvolts, or roughly ± 0.5 C at temperatures near 0 C. The readability and repeatability were about 0.1-0.2 C.

Figure 4 is a photograph of the recorder and switch box.

Cold Room

The interior dimensions of the room were 10 1/2 x 13 1/2 x 7 1/2 (high) ft. In one end, located about five feet above the floor, were the evaporating coils of the refrigeration unit. Air was moved over these coils by two 18-inch fans. The condensing unit was located outside the room and was driven by a 7 1/2 hp motor.

The mercury bulb type thermostatic control could be set to an accuracy of about 1 C.

Attached to the cold room was a vestibule in which the recorder, switch box, and cold junction were located.

Atmospheric Conditions

Air Temperature. The air temperature inside the cold room varied because of the nature of the thermostatic control. An average range of temperature after an air temperature drop was ± 2.5 C. The

thermostat on the unit was set so that the mean temperature in the room was the desired temperature.

Humidity. The relative humidity in the room during Series II tests was 90-100%.

Wind Velocity. The wind velocity immediately above the slabs varied from about 0.1 ft/sec to 6.0 ft/sec. These values are the horizontal velocities. It is known that there were also wind eddies which moved in a vertical direction onto the slab surfaces, but with the equipment available it was impossible to measure these.

While the differences in wind velocity are large, it is felt that, owing to the high relative humidity in the room, there was little difference in the evaporative cooling for the different slabs with the possible exception of the 6-in. slab with 1 in. of vermiculite-concrete insulation. This slab was placed in the area of lowest horizontal wind velocity, although there were known to be vertical movements in that area, as mentioned before.

Series I Preliminary Tests

In preparation for the Series I Preliminary Tests several initial experiments were run. In one test a slab that had thermocouples installed at the edges as well as at the center was tested. Results of this test showed that the heat flow at the middle of the slab is essentially one-dimensional when the edges are insulated with 4-in. of Styrofoam. Another test was run using two slabs which were identical except that one slab had reinforcing steel placed in it. Results of this test showed that differences in thermal behavior were so slight as to preclude the need for reinforcing steel in the test specimens.

For the Series I Preliminary Tests slabs were placed on their sides in the cold room, tested singly, and were dry on "top." Top, middle and bottom thermocouples were connected to the terminal board, and the slab was brought to a uniform temperature by cooling it for two days. Then during the actual test the room temperature was dropped as quickly as possible by 10 C from about + 7.5 C to about - 2.5 C. Readings were taken of the response of the slab for two hours after the test began by turning the switch from one thermocouple to the next every few seconds.

After completion of these tests, it was decided to test the slabs with water on the top to see if this had a significant effect on their thermal behavior. A low dike of putty was built around the perimeter of the concrete slabs in order that water might be ponded on top.

A preliminary test showed that the freezing of the water did affect the slab's behavior greatly and a test using five different slabs was performed. A description of that test follows.

Test I 20 C Drop - Type I Slabs

Five of the slabs prepared as stated above were used in this test. They were: 6-in. uninsulated; 6-in., 3/4-in. urethane; 6-in., 1/2-in. urethane; 7-in. uninsulated, and 7-in., 3/4-in. urethane, where the first figure is the slab thickness and the second that of the insulation. These slabs were arranged around the terminal board and were each supported on two 12-in. high styrofoam supports. Owing to a lack of operable thermocouple leads at this time only the top surface temperatures of the slabs could be recorded. The initial average air temperature was estimated to be that of the slabs. The final air temperature was estimated from the room thermostat control.

Eight minutes before the test began, about 500 ml. of water, which was at the temperature of the cold room, were poured onto each slab. Initial readings were taken and the cooling unit was turned down to a setting of - 20 C from an initial temperature of 2.5 C.

A reading was taken every ten seconds of a different thermocouple for the duration of the test. No observations of the freezing process of the water on the slabs were made.

Owing to mechanical problems with the cooling unit, it remained on during the entire test. That is, the room was constantly getting colder instead of being cooled quickly and then being maintained at that low temperature as it was in other tests.

As a result of this experiment and several uncertainties related to the curing of the slabs, their prior histories, the amounts of water used on the tops, and the temperature conditions, it was decided to prepare the six Series II slabs for further tests under more closely-controlled conditions.

Series II Tests

Preliminary tests were run on the Type II slabs to determine the effects, if any, of the precast mortar thermocouple support. This was done by casting a slab with the seven usual thermocouples and two additional ones placed so that the junction was immediately adjacent to the mortar support. Temperatures were then measured at the two locations, i.e. at the slab center and at the mortar support. It was found that the mortar support introduced no anomalies into the temperature measurements.

For Series II tests, six slabs were tested simultaneously and in a horizontal position. Each was placed on two 12-in. high Styrofoam

supports that rested on the floor. These slabs were arranged around the terminal board in a roughly hexagonal pattern, (see Figure 5). Since there were not sufficient terminals for all of the seven leads from each slab, only certain points were connected to the recorder. These points were: top surface, bottom surface (of the concrete), and three intermediate points. The air temperature was measured at a point about 4-in. above the top surface of one of the slabs.

For most of the Series II tests, the slabs were brought to a uniform temperature, water was added, and the ambient temperature was dropped below freezing. The thermal responses of the slabs were then measured. A detailed description of all final tests on Type II slabs follows.

Test II, Long Term Test

On November 14, 1963, a total of eight accidents in the Lafayette, Indiana area were caused by icy bridge decks. Temperature data were obtained for that day and for the week before from the Purdue University Agronomy Farm which is located about 6 miles northwest of West Lafayette. The accidents occurred during the period between 4 a.m. and 8 a.m. Thursday morning. A steady rainfall from Wednesday noon until late Wednesday evening at a temperature only 2 F above freezing had left the roads wet.

It was decided to simulate the climatic conditions for that week as closely as possible. A chart showing the actual temperature distribution and the temperature averages achieved in the laboratory test is given in Figure 6.

A large pan of water was exposed in the room early Wednesday morning in order to raise the relative humidity in the chamber;

250 ml of water, which were near room temperature, were placed on each slab at noon Wednesday. Testing began early Thursday morning, shortly after midnight, when the air temperature was lowered as shown in the figure.

During the days prior to the freeze, temperature readings had been taken intermittently. When the freeze test was being conducted readings were taken frequently.

Observations of the freezing process were made periodically by entering the room and taking notes on the severity of freezing on each slab.

<u>Test III, Thaw, - 2 C to + 12 C</u>

Ice, which had been on the slabs for three days at - 2 C, was used for a thaw test. Originally this ice was formed using 250 ml of water on each slab, but the fans in the room had, by the time this thaw test was run, sublimed an unknown portion of the ice.

After initial readings were taken and with the fans still on, the lights in the cold room were turned on, and the outer door was opened. The temperature rose from - 2 C to + 12 C during the period of the test.

Visual observations of the thawing process were made by entering the room and taking notes on the condition of the ice on the slabs.

<u>Test IV, Freeze, + 7.5 C to - 2 C</u>

In this test the six dry slabs were each initially at a uniform temperature of about 7.5 C. 250 ml of water at this were placed on top of each slab, and initial readings were taken. The test began ten minutes later at which time an average air temperature drop of 10 was obtained. Readings were taken every few seconds thereafter.

and visual observations of the freezing of the water on the slabs were made intermittently.

Test V, Freeze, + 10 C to - 10 C

In this test the six dry slabs were [illegible] initially at a uniform temperature of about [illegible] C. [illegible] ml of water at room temperature were placed on top of each slab, and initial readings were taken. The test began two minutes later [illegible] an average air temperature drop of 20 C was [illegible]. Readings were taken every few seconds thereafter, and visual observations of the freezing of the water on the individual slabs were made intermittently.

Test VI, Thaw, [illegible] to + [illegible]

In this test the six slabs were all initially dry and were each at a uniform temperature of about - [illegible] C. [illegible] ml of water which had a temperature of about + [illegible] C were poured onto each slab. This operation took about one minute.

Five hours later the slabs had again reached equilibrium at a temperature of about - [illegible] C with ice on top. Initial readings were taken, and the test was begun by opening the door of the room. The air temperature rise was about 27 C.

The reason for this new procedure, (i.e. starting with the slabs below zero but dry, freezing water on top of them, and then a few hours later running the thaw test), was to insure that each slab had the same amount of ice on it. It was decided to use this procedure after Test III had yielded questionable results, perhaps due to sublimation of portions of the ice that had been on the slabs for three days.

DATA

Series I (Preliminary) Tests

Data are presented in Figure 7 by plotting the percentage of the total air temperature drop attained by the top of the slab at various times in the experiment against the slab thickness.

Since the slabs were tested individually, and the cold room did not behave the same every time, it was thought that this method of presentation minimizes the varying temperature conditions.

The initial percentages are the percent of the air drop attained by the slab top surface at the time the refrigeration unit [illegible] the desired temperature. As an example, an initial percentage of 20 means that for an air temperature drop of 10 C, the top surface temperature of the slab fell 2 C.

The same idea is used for the percentages at 120 minutes, but the average air drop is used as a basis for the comparison.

Series I - Test [illegible]

The actual temperatures recorded for this test are given in Table 10 (Appendix). A top surface temperature-time plot is given in Figure 8. The point corresponding to zero time is when the air temperature was reduced, as described previously.

The cross-hatched area is an envelope that contains the maximum and minimum slab temperatures during freezing. All other slab temperatures are located within this envelope.

No visual observations were made during this test, and there were not a sufficient number of thermocouple terminals to allow slab temperature profiles (tautochrones) to be plotted.

Series II - Test II

The actual temperatures recorded for this test are given in Table 11 (Appendix). Owing to the duration of this test, a 24-hour clock notation was used as the time reference.

A temperature-time plot is given in Figure 9 for the entire test. For the sake of clarity, data points are connected with straight lines although this is not the actual temperature distribution between these points.

The critical period during which freezing of the water on the slabs occurred is shown in Figure 10. In this figure, an envelope is shown that contains the maximum and minimum slab temperatures. All other slab temperatures are located within this envelope.

No slab temperature profiles (tautochrones) were plotted for this test because the temperature differences during the freezing phase were so small.

Freezing progress observations for this test are given in Table 5. A further explanation of the symbols in this and similar tables follows.

0 Water was unfrozen over entire slab.

1 A few isolated ice crystals had formed.

2 An ice mush of many crystals had formed, or a very thin layer of solid ice had formed on the top surface of the water.

3 Portions of the ice were solid, but less than 50% of the top was in this condition.

4 More than 50% of the top was solid ice.

5 The top was completely solid ice with the exception of small areas adjacent to the concrete where water still remained.

6 The entire top was covered with solid ice.

TABLE 5

TEST II

FREEZING PROGRESS OBSERVATIONS

Slab	Time	00:06	01:38	02:12	03:37	04:17	05:25
6"-1" Urethane		0	2	2	5	6	6
6"-1 1/2" Urethane		0	1	2	5	5	6
6"-1" Vermiculite		0	1	2	5	5	6
6"-Uninsulated		0	1	2	5	6	6
6"-3/4" Urethane		0	2	2	5	5	6
7"-Uninsulated		0	0	1	5	5	6

Legend

0 Unfrozen

1 Few ice crystals

2 Many ice crystals or thin film of ice

3 Less than 50% solid ice

4 More than 50% solid ice

5 Almost completely solid ice

6 Solid ice

Series II - Test III

The temperatures recorded for this test are given in Table 12 (Appendix).

A top surface temperature-time plot is given in Figure 11. The point corresponding to zero time is when the air temperature was raised as described earlier.

The cross-hatched area is an envelope which contains the maximum and minimum slab temperatures during freezing. All other slab temperatures are located within this envelope.

Internal slab temperature distributions at given times (tautochrones) are shown in Figure 12. These figures show temperatures at specific depths in the concrete at the times noted. The bottom temperature of the 7-in. uninsulated slab is given in the same position as if its top surface and the 6-in. slabs' top surfaces were coplanar.

Thawing progress observations are given in Table 6. A further explanation of the symbols used in this and similar tables is as follows.

A All ice was completely thawed.

B Only small pieces of ice remained, or at the most, a thin layer of ice was adjacent to the concrete surface.

C Over 50% of the thickness of the ice was thawed.

D Less than 50% but more than 10% of the thickness of the ice had thawed.

E The ice surface was noticeably moist on top, but not more than 10% of the ice had melted.

F All ice was frozen solid on top of the slab.

TABLE 6

TEST III

THAWING PROGRESS OBSERVATIONS

Slab	Time 0*	17	28	47	65
6"-1" Urethane	F	E	D	A	A
6"-1 1/2" Urethane	F	E	D	A	A
6"-1" Vermiculite	F	E	E	B	A
6"-Uninsulated	F	E	E	B	A
6"-3/4" Urethane	F	E	D	A	A
7"-Uninsulated	F	E	E	C	A

*Due to the length of time (three days) the ice had been present, all slabs initially had small areas where there was no ice at all.

Legend

A	Thawed completely
B	Almost thawed completely
C	Greater than 50% thawed
D	Less than 50% thawed
E	Moist on top
F	Frozen solid

Series II - Test IV

The temperatures recorded for this test are given in Table 13 (Appendix).

A top surface temperature-time plot is given in Figure 13. The point corresponding to zero time is when the air temperature was lowered, as described earlier.

Internal slab temperature distributions at given times are shown in Figure 14. These figures show temperatures at specific depths in the concrete at the times noted. The bottom temperature of the 7-in. uninsulated slab is given in the same position as if its top surface and that of the 6-in. slab were coplanar.

Freezing progress observations are given in Table 7.

Series II - Test V

The actual temperatures recorded for this test are given in Table 14 (Appendix).

A top surface temperature-time plot is given in Figure 15. The point corresponding to zero time is when the air temperature was lowered, as described earlier.

The cross hatched area is an envelope that contains the maximum and minimum slab temperatures during freezing. All other slab temperatures are located within this envelope.

Internal slab temperature distributions at given times are shown in Figure 16. These figures show temperatures at specific depths in the concrete at the times noted. The bottom temperature of the 7-in. uninsulated slab is given in the same position as if its top surface and that of the 6-in. slab were coplanar. Freezing progress observations are given in Table 8.

TABLE 7

TEST IV

FREEZING PROGRESS OBSERVATIONS

Slab Time	0	240	261	293	328	358	388
6"-1" Urethane	0	0	1	1	2	2	4
6"-1 1/2" Urethane	0	0	1	1	1	2	3
6"-1" Vermiculite	0	0	0	0	1	1	2
6"-Uninsulated	0	0	0	1	2	3	5
6"-3/4" Urethane	0	0	1	1	2	3	5
7"-Uninsulated	0	0	1	1	2	4	5

Slab Time	432	455	472
6"-1" Urethane	5	6	6
6"-1 1/2" Urethane	5	6	6
6"-1" Vermiculite	4	5	6
6"-Uninsulated	6	6	6
6"-3/4" Urethane	6	6	6
7"-Uninsulated	6	6	6

Legend

0 Unfrozen

1 Few ice crystals

2 Many ice crystals or thin film of ice

3 Less than 50% solid ice

4 More than 50% solid ice

5 Almost completely solid ice

6 Solid ice

TABLE 8

TEST V

FREEZING PROGRESS OBSERVATIONS

Slab	Time	0	88	105	121	140	157
6"-1" Urethane		0	2	4	5	6	6
6"-1 1/2" Urethane		0	2	3	4	5	6
6"-1" Vermiculite		0	2	3	3	5	6
6"-Uninsulated		0	1	2	2	5	6
6"-3/4" Urethane		0	2	4	4	6	6
7"-Uninsulated		0	2	2	3	5	6

<u>Legend</u>

0	Unfrozen
1	Few ice crystals
2	Many ice crystals or thin film of ice
3	Less than 50% solid ice
4	More than 50% solid ice
5	Almost completely solid ice
6	Solid ice

Series II - Test VI

The actual temperatures recorded for this test are given in Tables 15 and 16. Table 15 contains temperatures during the time that water at 1 C was placed on the slabs, which were at about - 9.5 C. Table 16 gives temperatures recorded during the actual thaw test.

A top surface temperature-time plot is given in Figure 17 for the thaw test. The point corresponding to zero time is when the air temperature was raised to start the thaw.

The cross hatched area is an envelope that contains the maximum and minimum slab temperatures during freezing. All other slab temperatures are located within this envelope.

Internal slab temperature distributions at given times are shown in Figure 18. These figures show temperatures at specific depths in the concrete at the times noted. The bottom temperature of the 7-in. uninsulated slab is given in the same position as if its top surface and that of the 6-in. slab were coplanar. Thawing progress observations are given in Table 9.

TABLE 9

TEST VI

THAWING PROGRESS OBSERVATIONS

Slab	Time	0	42	57	92	113	131	153
6"-1" Urethane		F	F	E	E	D	C	C
6"-1 1/2" Urethane		F	F	E	E	D	C	C
6"-1" Vermiculite		F	F	E	E	E	E	D
6"-Uninsulated		F	F	E	E	E	D	C
6"-3/4" Urethane		F	F	E	E	D	C	C
7"-Uninsulated		F	F	E	E	E	C	C

Slab	Time	170	181	197	210
6"-1" Urethane		C	B	A	A
6"-1 1/2" Urethane		C	B	A	A
6"-1" Vermiculite		C	C	B	A
6"-Uninsulated		C	B	A	A
6"-3/4" Urethane		C	B	A	A
7"-Uninsulated		C	B	A	A

<u>Legend</u>

A Thawed completely

B Almost thawed completely

C Greater than 50% thawed

D Less than 50% thawed

E Moist on top

F Frozen solid

DISCUSSION

Series I (Preliminary) Tests

The results given in Figure 7 show that for a dry surface there is no significant effect on the top surface temperature of insulating the underside of the slab.

Although there is some variance in the values, it is within the limits of accuracy of the test method. For example, while a 7-in. uninsulated slab's top temperature fell 2.7 C for a 10 C air temperature drop, a similar slab insulated with 1-in. of urethane foam fell 2.6 C. Similar results can be found elsewhere in these data.

Some of the discrepancies can be attributed to small differences in the testing procedures. Since the slabs were cast singly, they then were required, in order to have had like curing conditions, to be tested individually. During the total testing period, the refrigeration unit lost some efficiency and required progressively longer times to cool the air by the desired amount.

The slabs that were tested with the top surface wet show a marked increase in percentage of temperature drop of the tops compared to the dry slabs. This is due to the evaporative cooling of the moisture on the slab surfaces.

It should be noted that this temperature drop of about 10 C took an average of only 20 min. to occur. This 10 C drop is equivalent to an 18 F drop. Thus, it is felt that a far "worse" condition existed in the laboratory than actually takes place normally in the field. The result of this greater severity would be to enhance any effects of the insulation.

Test I

This test, using five Type I slabs, was the first in which water was ponded on top of the slabs.

Results, which are given in Figure 8, show several effects that could be attributed to the insulation.

With the exception of the 7-in. slab with 3/4-in. of urethane foam, all slabs began to freeze at the same time; the exceptional slab began to freeze 20 minutes after the other four. The length of time for each slab completely to freeze was as follows:

6" - Uninsulated	115 min.
6" - 3/4" Urethane	140 min.
6" - 1 1/2" Urethane	140 min.
7" - Uninsulated	125 min.
7" - 3/4" Urethane	170 min.

A partial explanation of the results shown on this figure could be the different curing times (with correspondingly differing moisture contents) of the five different slabs. A change in the moisture content of concrete changes the values of its thermal properties. These slabs, which were originally planned to be tested singly after specified curing times and conditions, were in this experiment tested together. As an example, the 6-in. uninsulated slab was the oldest of the five, having been cast more than two months before the 7-in. slab with 3/4-in. of urethane foam. The 7-in. uninsulated slab was ten days younger than the 7" - 3/4" urethane slab, but it had dried with both the top and bottom surfaces exposed to the air, and thus probably had a lower moisture content than the 7" - 3/4" urethane slab.

Also, in this test, 500 ml. of water were used on top of the slabs. This amount gave an average depth of water on the surface of almost 1/4-in. It is felt that this was an abnormally large amount of water, since most bridges are drained well enough so that there is seldom such an accumulation of moisture. This greater amount of water enhances effects of the insulation, as does the relatively large temperature drop (in this instance, 20 C) over a small time compared to normally-encountered conditions.

Therefore, it is believed these results tend to emphasize any beneficial effects of the insulation. It could, however, be concluded that under certain (severe) conditions some desired effect could be obtained.

Series II Tests

Test II

The results of this thaw test are given in Figures 9 and 10 and in Tables 5 and 11 (Appendix).

It should be noticed in Figure 9 that the insulation tends to moderate the large temperature changes that take place in the slabs. Here again, though, the maximum difference is only 1 C. After several hours slab top temperatures are close to each other and, to the accuracy attainable, they may be considered to be the same.

In Figure 10 and Table 5, it can be seen that during the critical freezing portion of the test, the water on the slabs began to freeze at the same time, and was completely frozen at the same time. The total freezing time was 300 minutes, or five hours. It is interesting to note that the first accident on the bridge after which this test procedure was patterned occurred at 4:30 a.m., or roughly 4 1/2 hr.

after the onset of subfreezing air temperatures. Thus, the similarity between field conditions and the laboratory environment can be seen.

It can be hypothesized that this test resembles actual field conditions more closely than do any of the others in this study. The air drop of 2 C (or 3.6 F) is more realistic than, for example, a 20 C (or 36 F) drop occurring within twenty minutes. Also, an average long-term temperature drop in the field could be closely approximated by taking several 2 C drops in succession, but at intervals of, say, an hour or two. The conclusion would be, by extending the results of the test now being discussed, that the insulation would not have a significant effect on any phase of the freezing process.

It is thus felt that Test II should be regarded as significant in the final analysis.

Test III

Results for this thaw test are given in Figures 11 and 12 and Tables 6 and 12 (Appendix).

This test was of short duration; total thawing time was less than 60 min.

The graphical results (Figure 11) show that the insulated slabs preceded the uninsulated slabs in thawing, since their temperatures rise from the thawing zone the earliest. However, the visual thawing progress observations (Table 6) show a less pronounced difference.

It should be noted that, owing to the length of time (three days) that the ice had been present, all the slabs had small areas where there was no ice. This sublimation resulted in an uncertain amount of ice on top of each slab. For this reason, it is believed that these results are somewhat inconclusive, and it was because of this

uncertainty that the procedure for Test VI was developed so that the same amount of fresh ice would be on each slab at the start of the thaw.

Test IV

Results for this freeze test are given in Figures 13 and 14, and in Tables 7 and 13 (Appendix).

It should be observed in Figure 13 that the maximum difference in top surface temperatures during the period preceding freezing is 1 C. The 7-in. uninsulated slab began to freeze first, followed about 20 minutes later by the 6-in. uninsulated slab. The remainder of the slabs froze almost at the same time as the 6-in. slab. The 7-in. uninsulated slab was totally frozen first also, preceding the others by about 30 minutes.

Although the top temperature-time figure shows the above results, visual observations of the slabs (Table 7) show that the freezing behavior of the slabs was nearly the same at all times with the exception of the 6-in. slab insulated with the 1-in. layer of vermiculite concrete.

As was discussed earlier, the wind distribution in the cold room was not completely uniform. Due to the space available, it was necessary that one slab be placed in an area of low horizontal wind velocity. Since it was felt that the slab with vermiculite-concrete insulation was of the least practical importance, it was chosen for this position. This may be the reason that top surface temperatures remained slightly higher on this slab, in general, on all tests.

An examination of the top surface thermocouple position on the slab with vermiculite-concrete insulation showed that it was about twice as deep (1/8 in.) as the thermocouple depth on the other slabs

(1/16-in. or less). Since the change in the thermal gradient is greatest near the top surface, this slight difference in depth would also contribute somewhat to the "better" results obtained from this slab in nearly all tests.

Test V

Results for this freeze test are given in Figures 15 and 16 and in Tables 8 and 14 (Appendix).

The results of this test, which was the most severe freeze (19.5 C air drop = 35 F), were that the slabs began to freeze at the same time, and were completely frozen at the same time. It may be noted that there were slight differences in the time of freezing, but these are believed to be insignificant in proportion to the total freezing time and with respect to the large air temperature drop.

The maximum difference in top surface temperatures was 1.3 C preceding freezing.

It is believed that the behavior of the 6-in. slab with 1-in. of vermiculite-concrete insulation can again be explained by the reasons given previously.

Particularly interesting to note are the tautochrones (Figure 16), which show markedly the effect of the insulation near the bottom of the slab in keeping the temperatures up to 6 C warmer than the uninsulated slab. However, it can also be noticed that there is little effect near the top. The thermal gradient (slope of the tautochrones) is greater for the insulated slabs, but this additional heat is insignificant compared to the heat lost by the freezing water to the moving air. This is shown by the consistent results that the freezing behavior of all slabs was essentially the same.

Test VI

The results of this thaw test are given in Figures 17 and 18 and Tables 9 and 15 and 16 (Appendix).

Results of this severe thaw test (a temperature rise of 27 C or 48 F) are that, with the exception of the vermiculite-insulated slab, all slabs began to thaw at the same time, and the 6-in. uninsulated slab was completely thawed about 20 minutes before the corresponding insulated slabs. The 7-in. uninsulated slab was the second to thaw and followed the 6-in. uninsulated slab by about 10 minutes.

The behavior of the vermiculite-insulated slab can perhaps again be explained along lines previously discussed.

This test is thought to be particularly significant, not only because of the severe conditions imposed, but also the test procedure wherein the ice being thawed was as uniform as possible among the several test slabs.

The tautochrones for this test (Figure 18) also show clearly the effect of the insulation near the bottom. While the heat flow from the slab is into the top surface on the uninsulated slabs, it is out of the top on the insulated slabs. Thus the ice on the uninsulated slabs is being warmed both by the air and from within the slabs, while the ice on the insulated slabs is being warmed by the air, but cooled from within the slab. This would account for the slightly earlier times when the two uninsulated slabs are completely thawed. It is important to note that this was the only time that such behavior was noticed in any of the tests conducted, and this test was by far the most severe so far as the air temperature change was concerned.

With respect to all the results of this program, it should be noted that the 6-in. thickness of the test samples is less than that frequently used on bridge decks. This aspect can be expected to accentuate any effects of the insulation, and on thicker decks the effects would be even less than those small ones shown by this work.

It should also be remembered that the conditions in the cold room simulated nighttime, i.e. there was no solar energy. The slight effects the insulation had on the thawing behavior of the test slabs would probably be far outweighed by solar energy if the thaw occurred in the daytime, as it usually does.

SUMMARY

The important findings of this investigation can be summarized as follows:

There were no significant differences in the top surface temperatures of the insulated and uninsulated slabs when the surfaces were dry or when they were wet, but no freezing of the moisture took place.

Over a long period of time during fluctuating temperatures, the insulation tended to moderate slightly the top temperatures of insulated slabs compared with uninsulated ones. However, this moderation would probably be insignificant under normally-occurring field temperature variations.

For an air temperature drop from just above freezing to just below freezing, there were no significant differences in the top surface temperatures of the slabs, nor were there any differences in the freezing behavior of the water on the slabs.

For a sudden, large air temperature drop, there was a small delay, due to insulation, both in the start of freezing and in the attainment of the totally frozen state.

For a sudden, large air temperature rise, there was a small delay, due to insulation, both in the start of thawing and in the attainment of the totally thawed state.

Differences in thermal behavior of the slab top surfaces due to differing amounts of insulation on the bottoms were insignificant.

The insulation kept the bottoms and interiors of the slabs warmer and increased the amount of heat flow from the interior to the top, but this amount of heat was small compared to that lost by the freezing water to the surrounding air.

CONCLUSIONS

The temperatures and slab thicknesses used in this study represent, for the most part, conditions harsher than those usually found in the field. They would, therefore, tend to accentuate any effects of slab insulation.

Based on the samples tested and the tests performed, it is concluded that insulation of the underside of a concrete bridge deck with foamed plastic insulation has no significant effects on the prevention of early icing of the deck under most field conditions.

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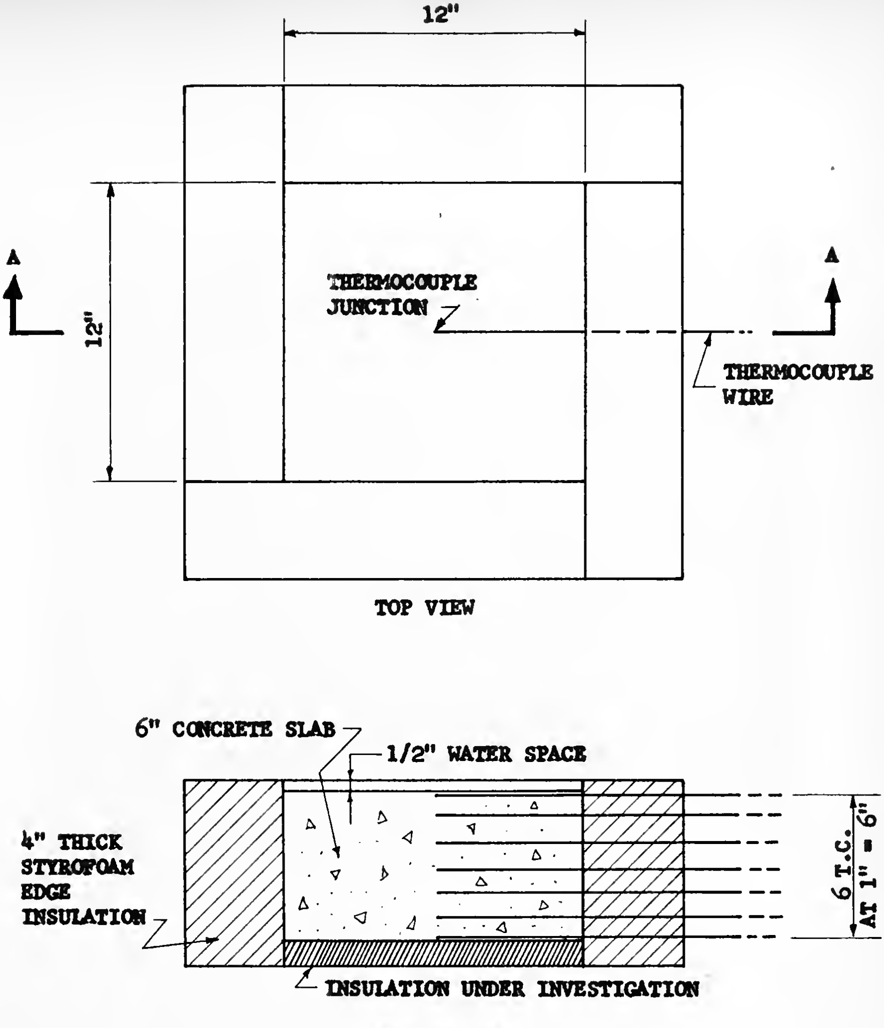


NOTE: TYPE I FORMS HAD ONLY 3 THERMOCOUPLES (TOP, MID-DEPTH, AND BOTTOM), AND DID NOT HAVE 1/2" WATER SPACE.

FIG. 1

TYPE II FORM CONSTRUCTION

FIG. 2
TYPE I FORM

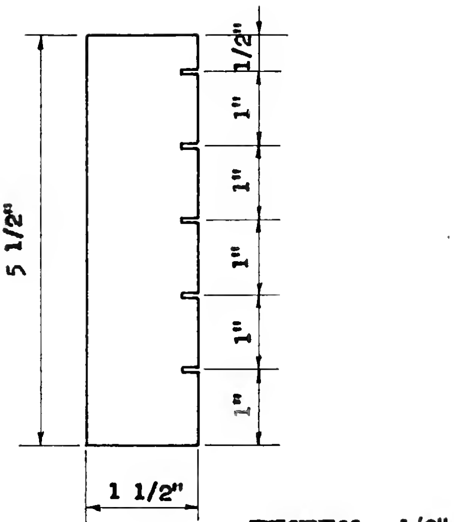


FIG. 3

MORTAR THERMOCOUPLE SUPPORT

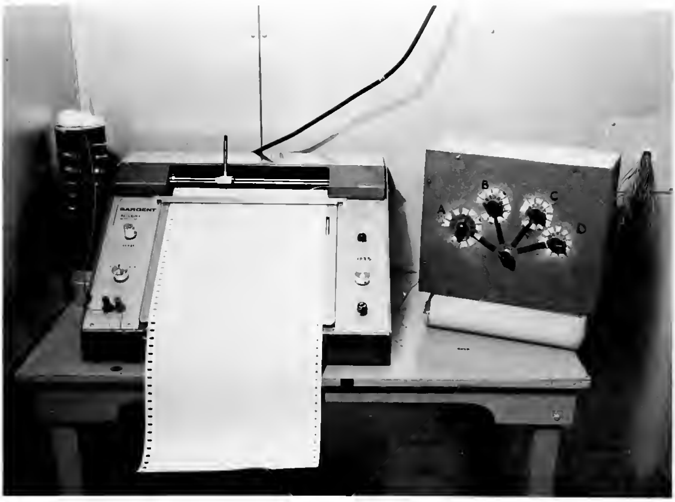


FIG. 4
RECORDER, SWITCH BOX, AND
THERMOCOUPLE COLD JUNCTION
ICE BATH

FIG. 5

SERIES II TESTING ARRANGEMENT
INSIDE WALK-IN COLD ROOM

TEMPERATURE (°C)

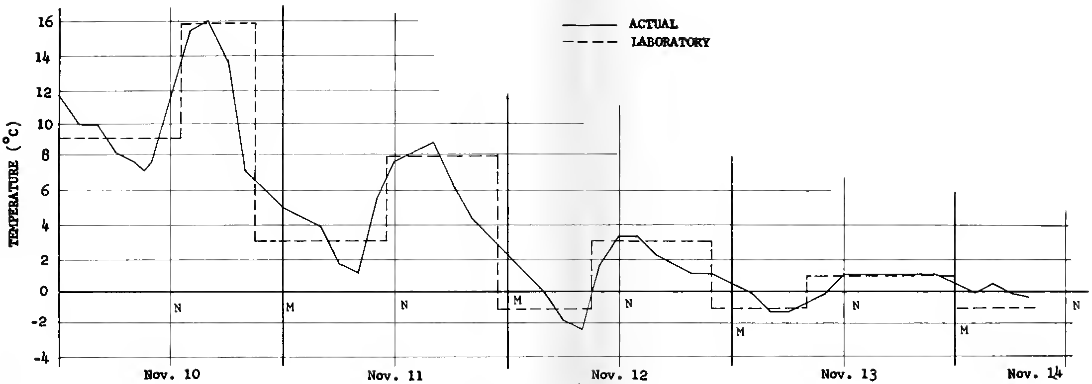
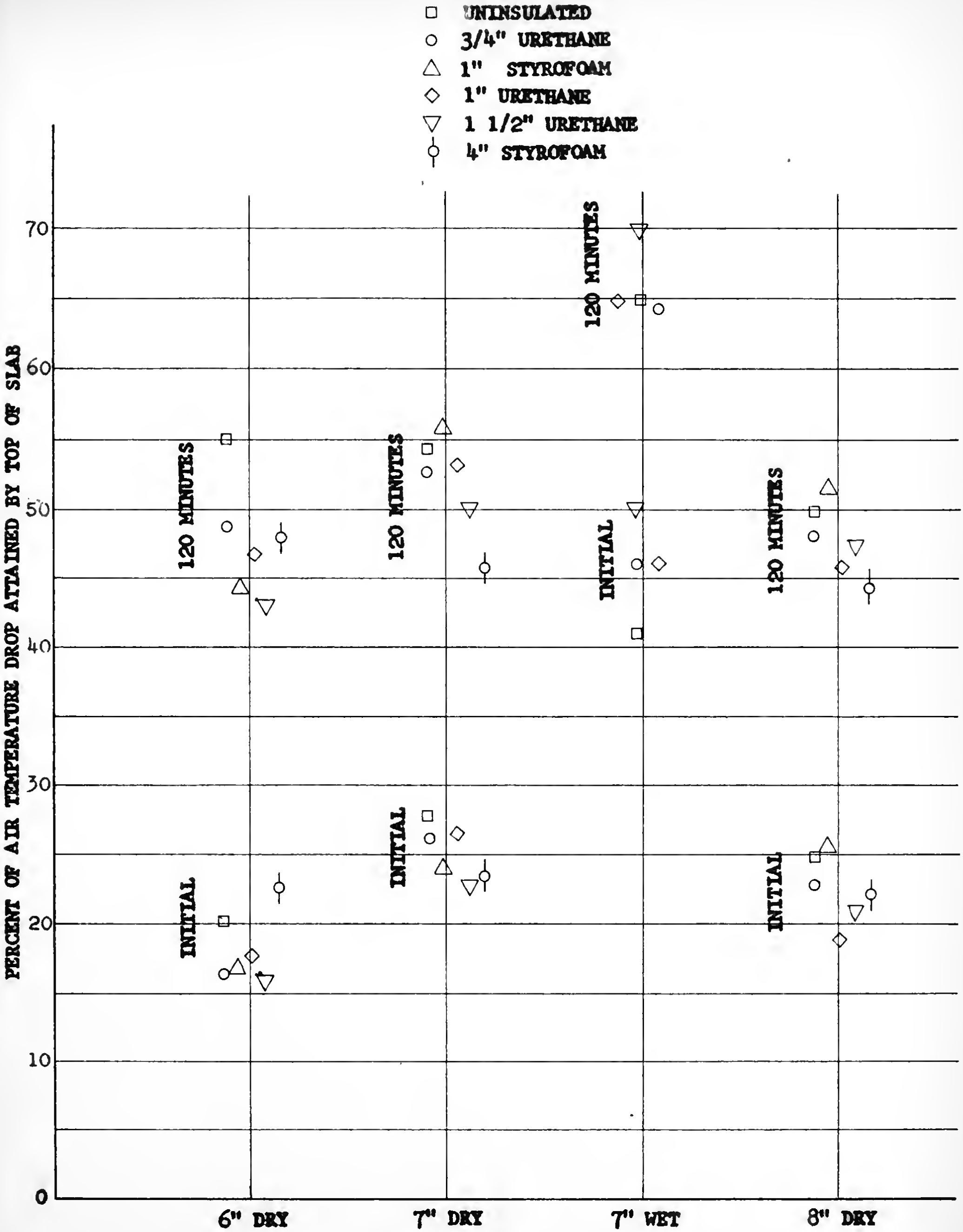


FIG. 6
TEMPERATURE DATA
PURDUE AGRONOMY FARM
NOVEMBER 10-15, 1963



SERIES I
PRELIMINARY TESTS

FIG. 7

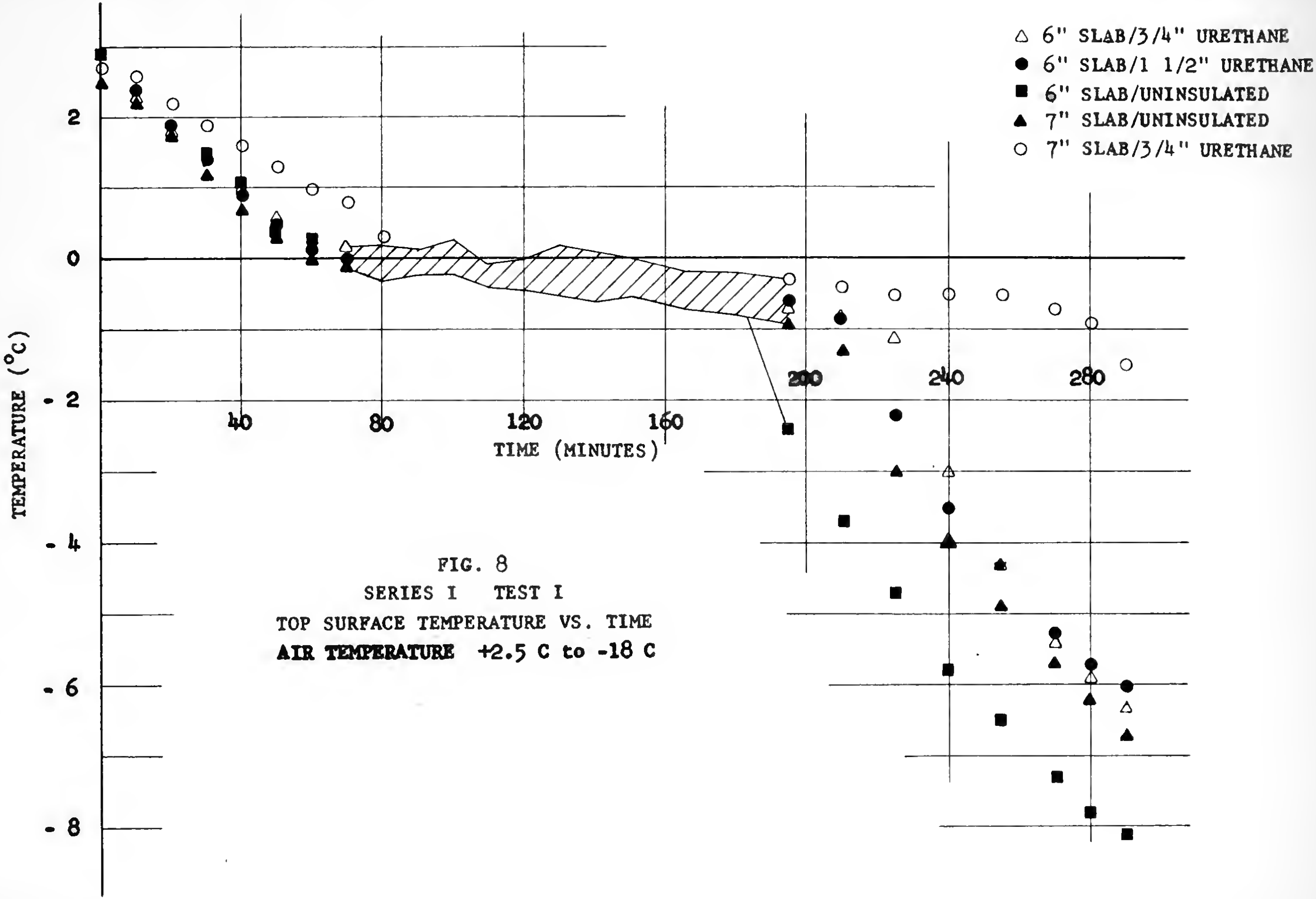


FIG. 8

SERIES I TEST I

TOP SURFACE TEMPERATURE VS. TIME

AIR TEMPERATURE +2.5 C to -18 C

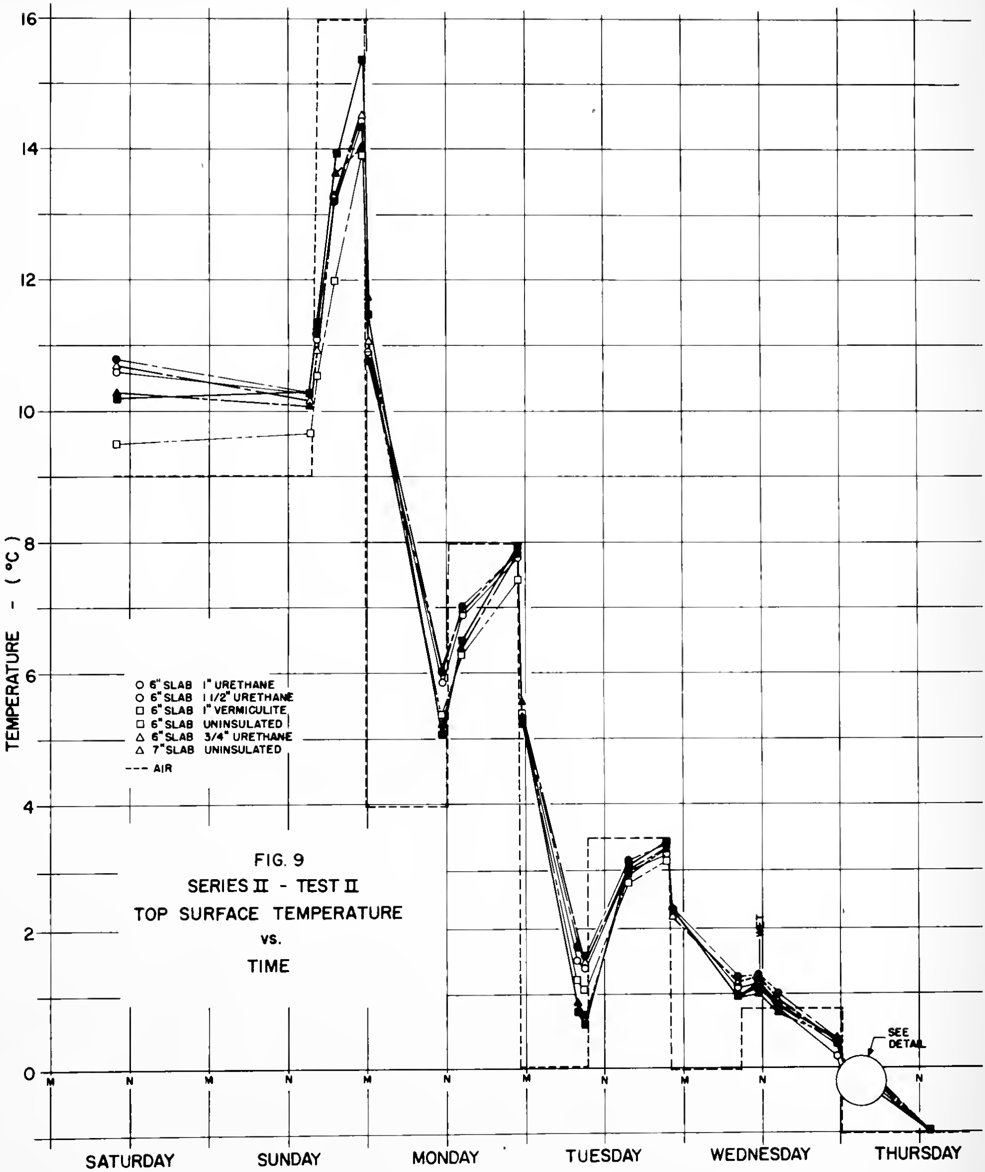
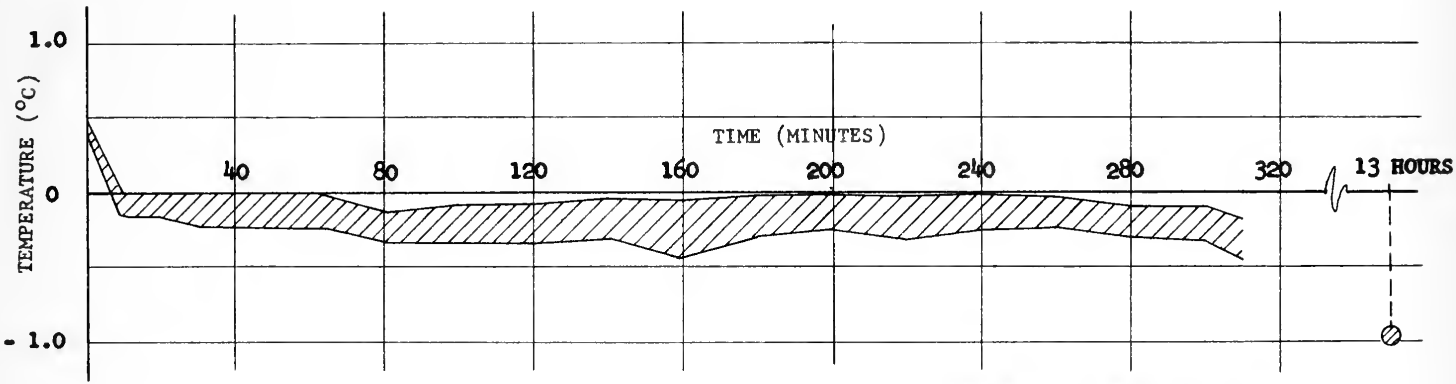


FIG. 9
SERIES II - TEST II
TOP SURFACE TEMPERATURE
vs.
TIME

SLABS TESTED: 6" SLAB/UNINSULATED
6" SLAB/3/4" URETHANE
6" SLAB/1" URETHANE
6" SLAB/1 1/2" URETHANE
6" SLAB/1" VERMICULITE
7" SLAB/UNINSULATED



SERIES II TEST II
DETAIL AT TIME OF FREEZING
TOP SURFACE TEMPERATURE VS. TIME
ENVELOPE OF ALL 6 SLABS' DATA
AIR TEMPERATURE +1 C to -1 C

FIG. 10

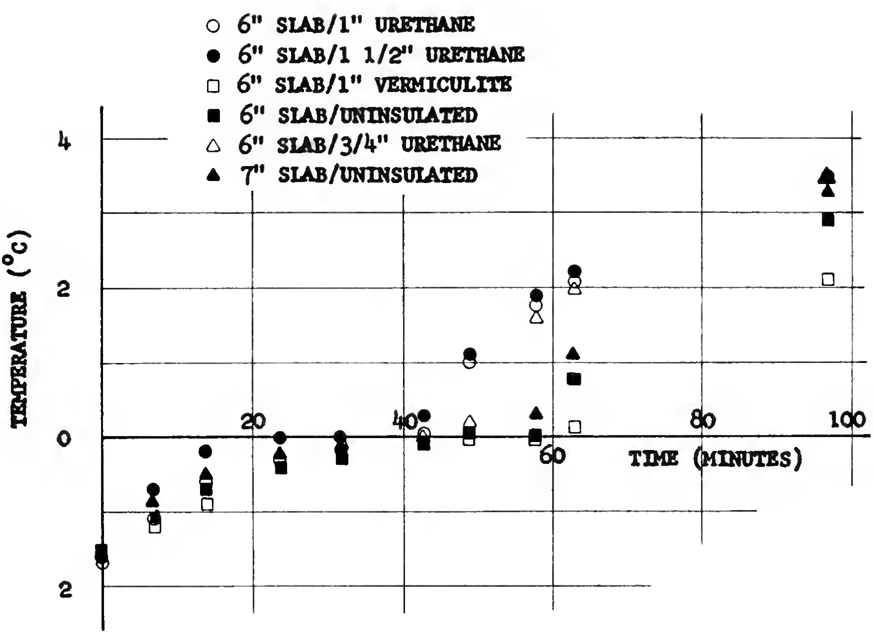
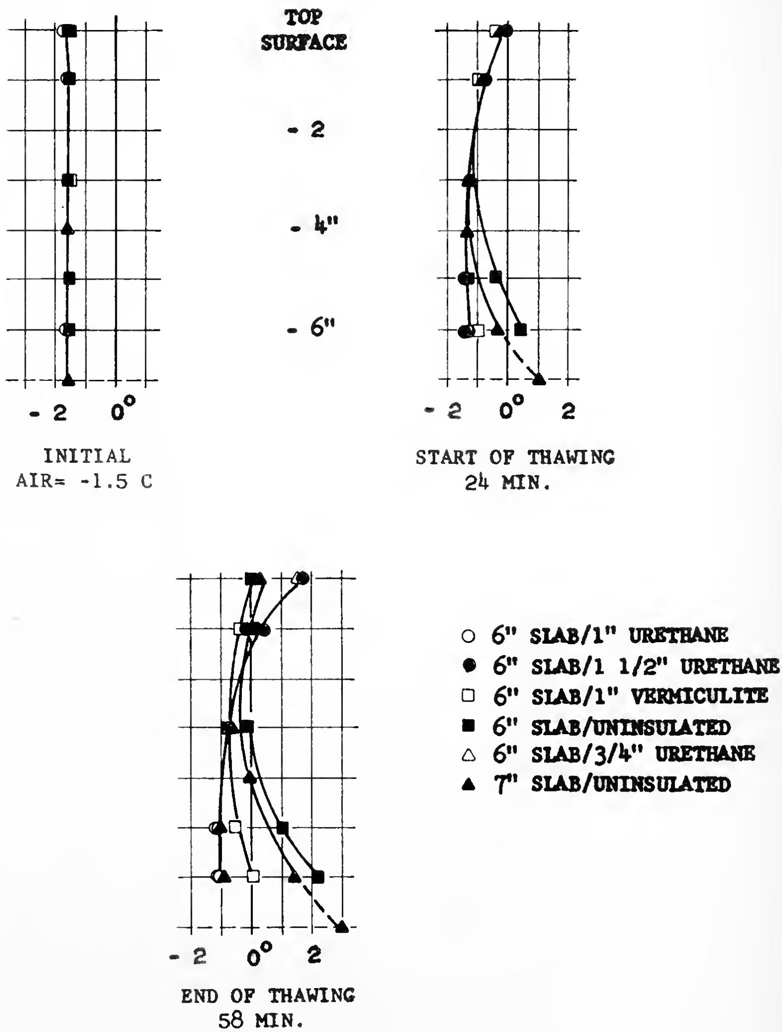


FIG. 11

SERIES II TEST III

TOP SURFACE TEMPERATURE VS. TIME

AIR TEMPERATURE -2 C to +12 C



NOTE: THERE IS NO FIGURE BETWEEN INITIAL AND 24 MIN. BECAUSE NO PERTINENT INFORMATION IS SHOWN.

SERIES II TEST III

TAUTOCHRONES

FIG. 12

TEMPERATURE (^{o}C)

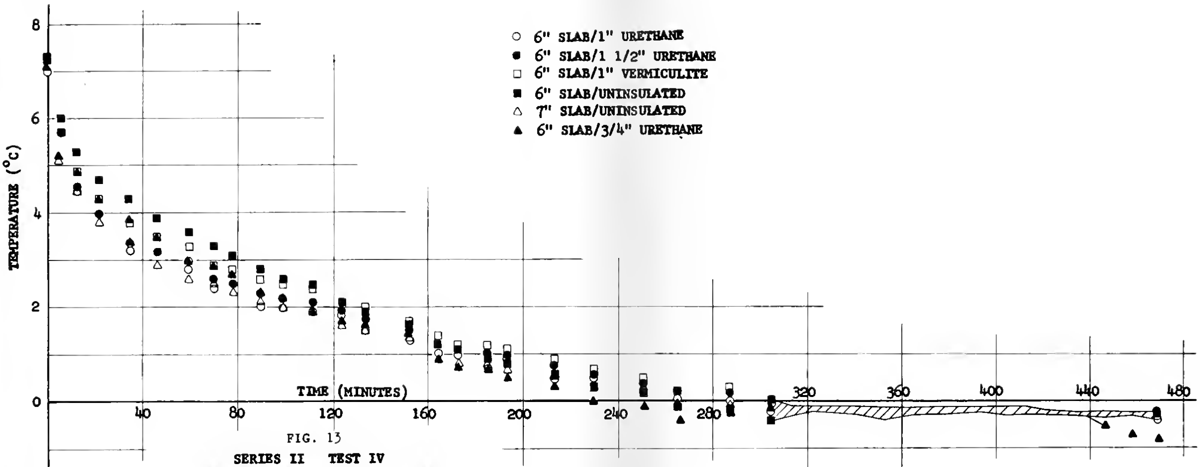


FIG. 13

SERIES II TEST IV

TOP SURFACE TEMPERATURE VS. TIME

AIR TEMPERATURE +8 C to -2 C

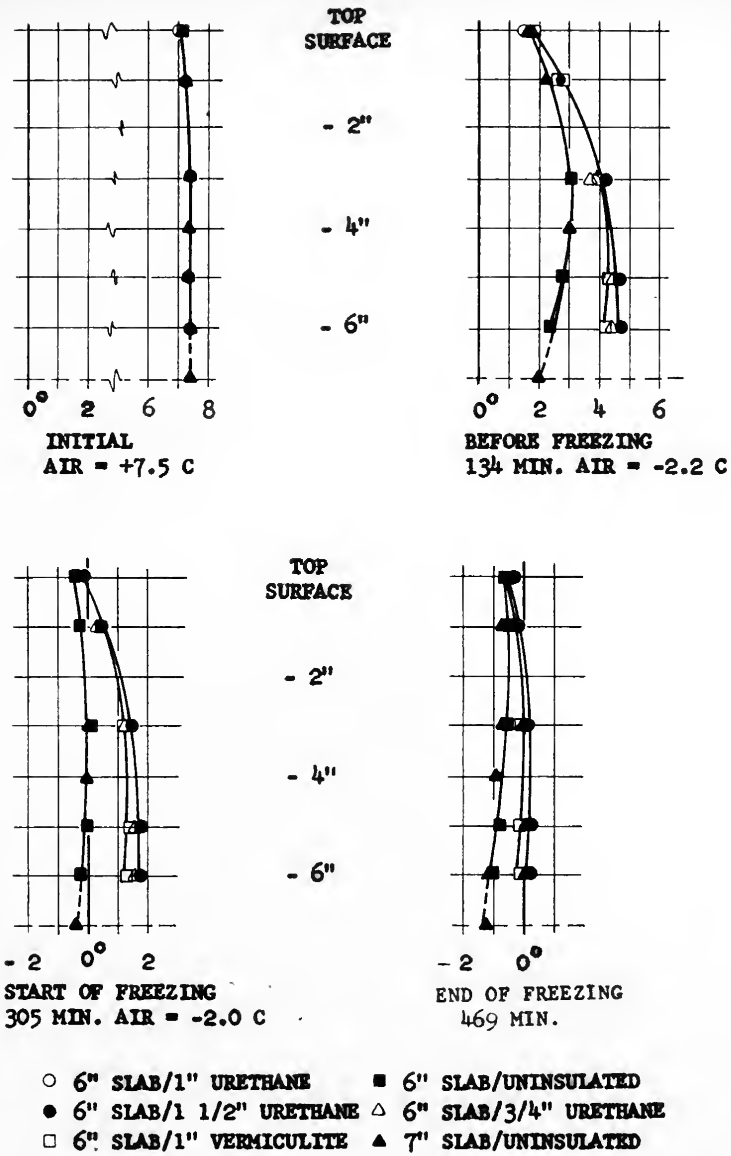
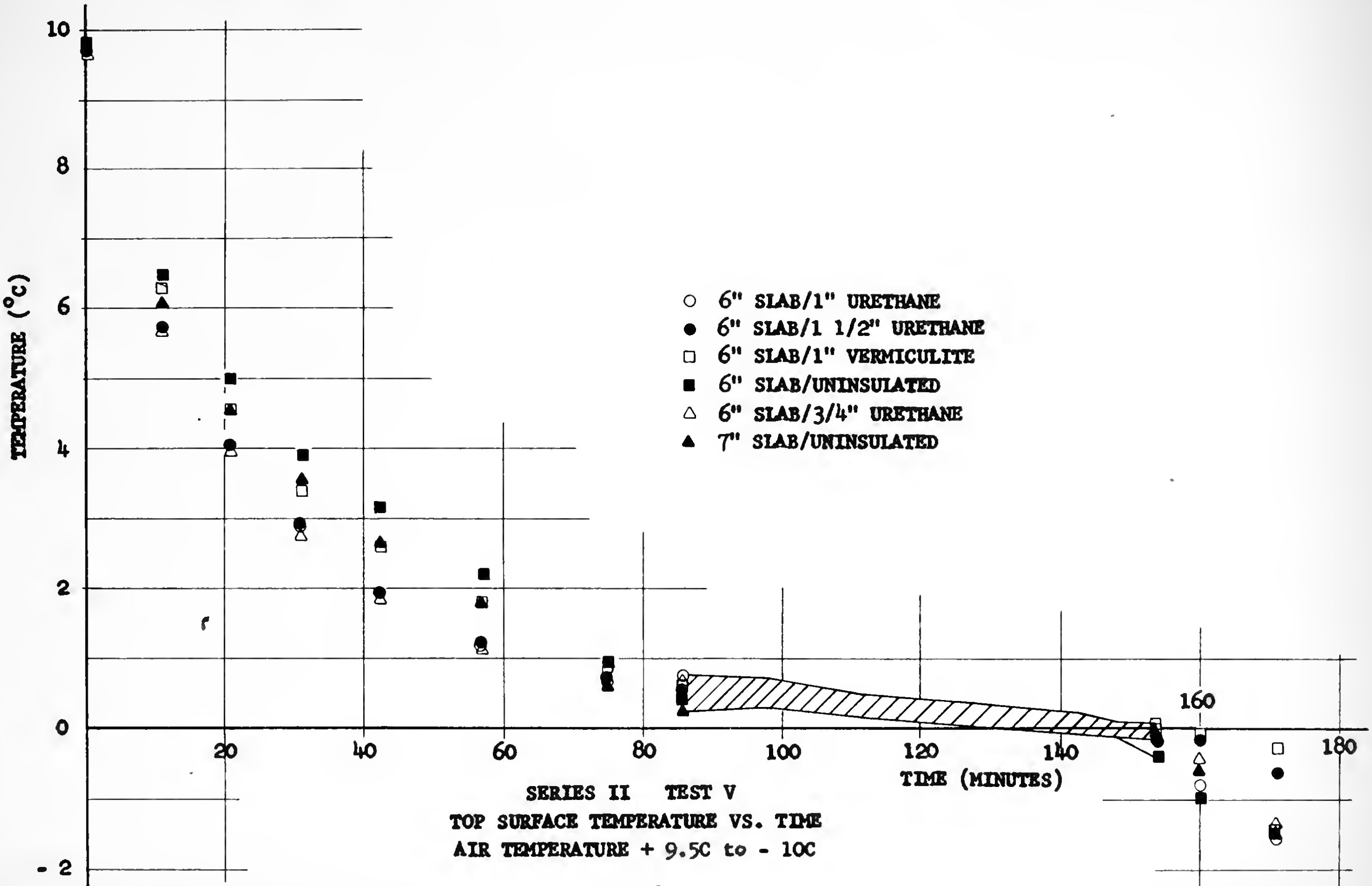


FIG. 14

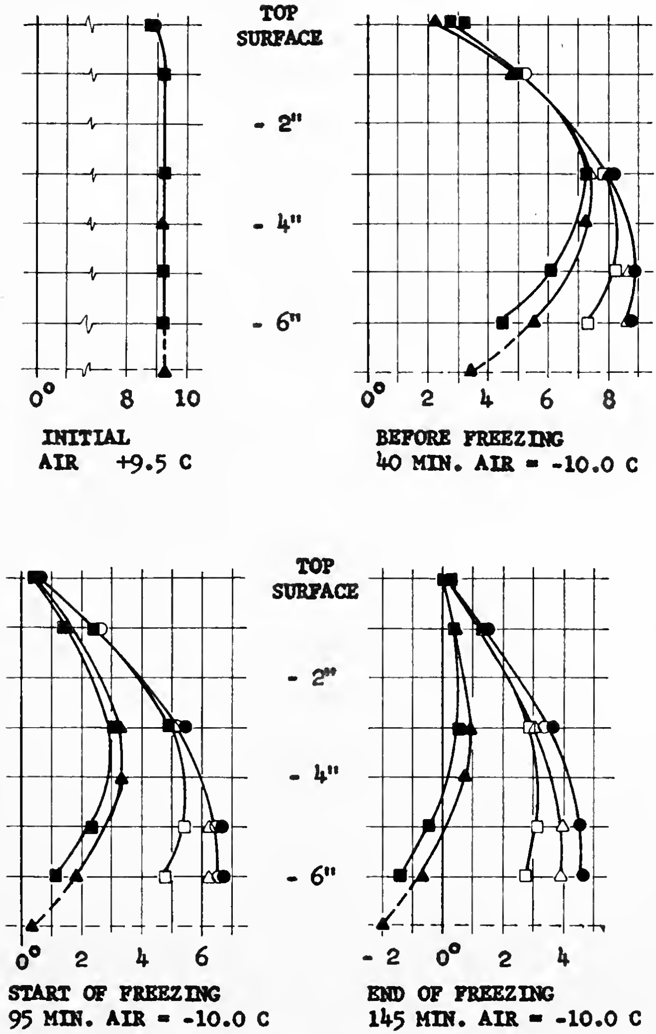
SERIES II TEST IV

TAUTOCHRONES



SERIES II TEST V
TOP SURFACE TEMPERATURE VS. TIME
AIR TEMPERATURE + 9.5C to - 10C

FIG. 15

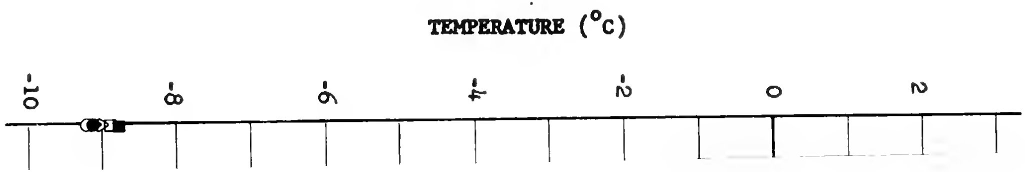


○ 6" SLAB/1" URETHANE ■ 6" SLAB/UNINSULATED
● 6" SLAB/1 1/2" URETHANE △ 6" SLAB/3/4" URETHANE
□ 6" SLAB/1" VERMICULITE ▲ 7" SLAB/UNINSULATED

FIG. 16

SERIES II TEST V

TAUTOCHRONES


TEMPERATURE (°C)
-10
-8
-6
-4
-2
0
2

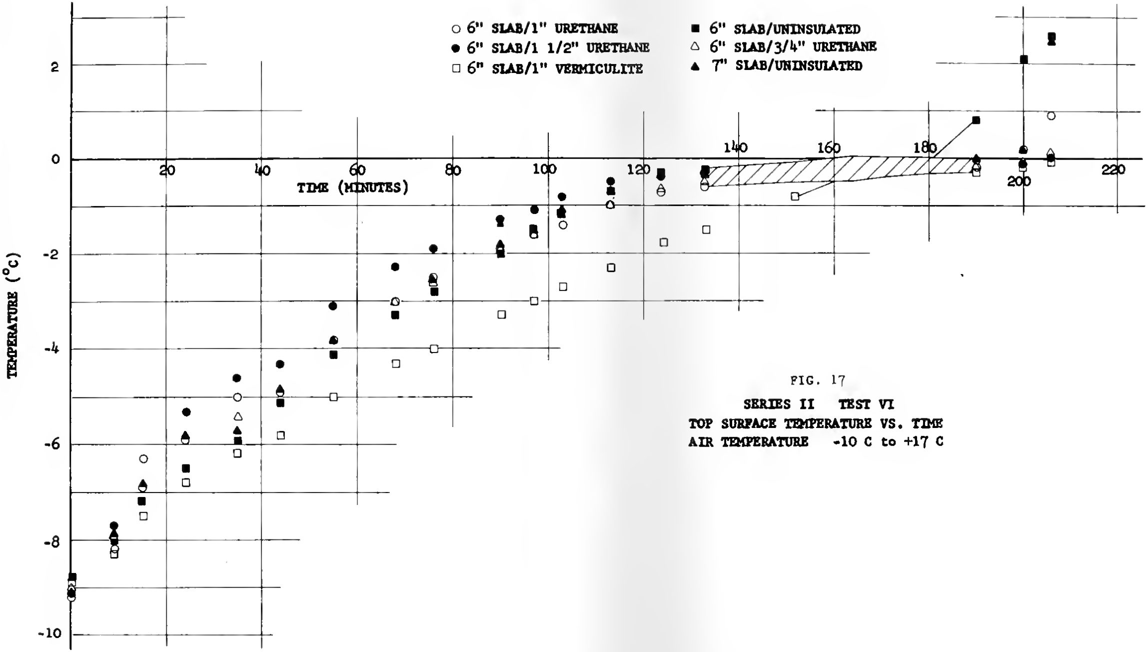
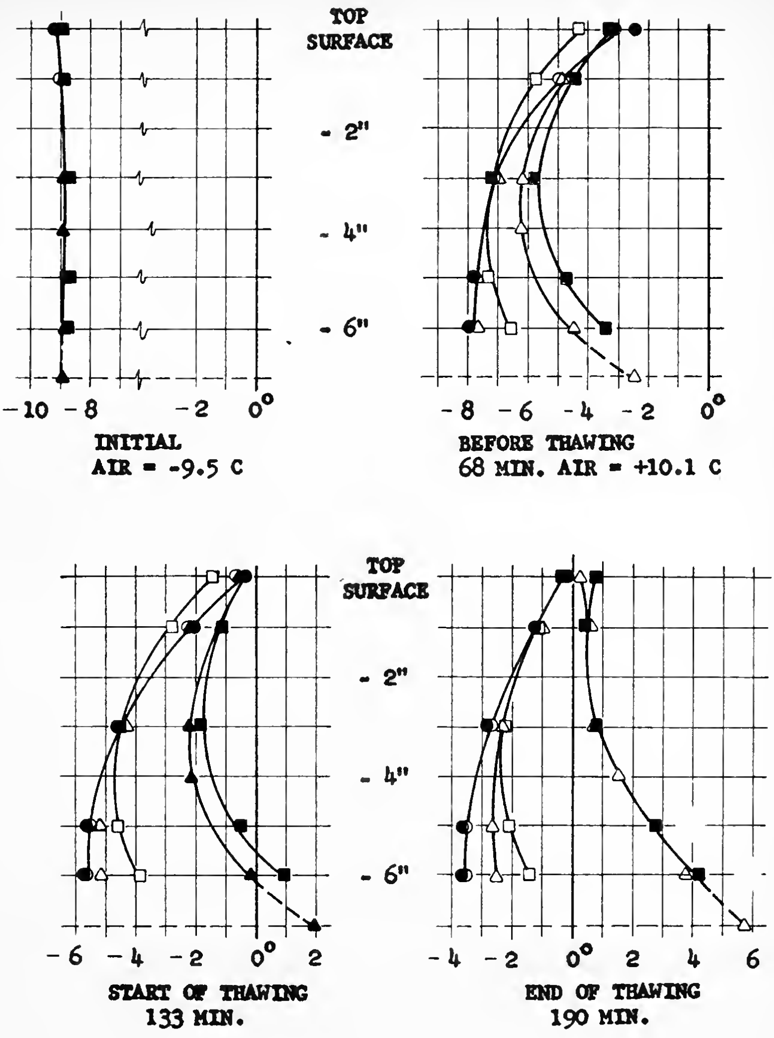


FIG. 17

SERIES II TEST VI

TOP SURFACE TEMPERATURE VS. TIME

AIR TEMPERATURE -10 C to +17 C



○ 6" SLAB/1" URETHANE ■ 6" SLAB/UNINSULATED
● 6" SLAB/1 1/2" URETHANE △ 6" SLAB/3/4" URETHANE
□ 6" SLAB/1" VERMICULITE ▲ 7" SLAB/UNINSULATED

FIG. 18

SERIES II TEST VI

TAUTOCHRONES

TABLE 10

TEST I SLAB TEMPERATURES

Slab	Time	0	10	20	30	40	50	60	70
Air		2.5							
7"-3/4" Urethane Top Surface		2.7	2.6	2.2	1.9	1.6	1.3	1.0	0.8
7"-Uninsulated Top Surface		2.5	2.2	1.7	1.2	0.7	0.3	0.0	-0.1
6"-3/4" Urethane Top Surface		2.5	2.3	1.8	1.5	1.0	0.6	0.2	0.2
6"-1 1/2" Urethane Top Surface		2.7	2.4	1.9	1.4	0.9	0.5	0.1	0.0
6"-Uninsulated Top Surface		2.9	2.4	1.9	1.5	1.1	0.4	0.3	0.6

Slab	Time	80	90	100	110	120	130	140	150
Air			-10.5				-11.0		
7"-3/4" Urethane Top Surface		0.3	0.1	0.0	-0.1	0.0	-0.1	-0.2	-0.2
7"-Uninsulated Top Surface		-0.3	-0.2	-0.2	-0.4	-0.4	-0.5	-0.6	-0.5
6"-3/4" Urethane Top Surface		0.0	0.0	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3
6"-1 1/2" Urethane Top Surface		0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.4
6"-Uninsulated Top Surface		0.2	0.1	0.3	-0.1	-0.1	0.2	0.1	0.0

Slab	Time	165	180	195	210	225	240	255	270
Air		-13.0		-14.5	-15.5			-17.0	-18.0
7"-3/4" Urethane Top Surface		-0.2	-0.2	-0.3	-0.4	-0.5	-0.5	-0.5	-0.7
7"-Uninsulated Top Surface		-0.7	-0.8	-0.9	-1.3	-3.0	-4.0	-4.9	-5.7
6"-3/4" Urethane Top Surface		-0.5	-0.5	-0.7	-0.8	-1.1	-3.0	-4.3	-5.4
6"-1 1/2" Urethane Top Surface		-0.5	-0.4	-0.6	-0.8	-2.2	-3.5	-4.4	-5.3
6"-Uninsulated Top Surface		-0.4	-0.4	-2.4	-3.7	-4.7	-5.8	-6.5	-7.3

TABLE 10 (Cont'd)

Slab	Time	280	290
Air			
7"-3/4" Urethane			
Top Surface		-0.9	-1.5
7"-Uninsulated			
Top Surface		-6.2	-6.7
6"-3/4" Urethane			
Top Surface		-5.9	-6.3
6"-1 1/2" Urethane			
Top Surface		-5.7	-6.0
6"-Uninsulated			
Top Surface		-7.8	-8.1

TABLE 11

TEST II SLAB TEMPERATURES*

DECEMBER 13

Slab	Time	14:40	15:17	15:27	16:51	17:05
Air		21.0	0.9	1.6	10.8	9.1
6"-1" Urethane						
	Top Surface	21.9	18.6	18.2	16.5	16.0
	-1"	21.9	20.5	20.0	17.7	17.4
	-3"	22.0	21.7	21.4	19.1	18.8
	-5"	22.0	21.9	21.8	19.8	19.6
	-6"	22.0	21.9	21.8	19.9	19.6
6"-1 1/2" Urethane						
	Top Surface	22.0	18.6	18.2	16.8	16.4
	-1"	22.1	20.4	20.0	17.9	17.6
	-3"	22.2	21.9	21.7	19.5	19.3
	-5"	22.2	22.1	22.1	20.1	19.9
	-6"	22.2	22.1	22.0	20.2	19.9
6"-1" Vermiculite						
	Top Surface	19.2	16.6	16.3	14.7	14.2
	-1"	19.0	17.7	17.3	15.1	14.8
	-3"	18.7	18.4	18.1	15.6	15.2
	-5"	18.4	17.9	17.5	15.2	14.9
	-6"	18.2	16.7	16.5	14.4	14.1
6"-Uninsulated						
	Top Surface	21.3	18.0	17.6	15.5	14.9
	-1"	21.3	19.1	18.7	16.0	15.5
	-3"	21.3	20.6	20.1	16.8	16.4
	-5"	21.3	19.8	19.5	16.4	16.0
	Bottom Surface	21.3	18.9	18.5	15.9	15.4
6"-3/4" Urethane						
	Top Surface	21.7	18.7	18.3	16.8	16.4
	-1"	21.8	20.1	19.7	17.7	17.3
	-3"	21.8	21.4	21.1	18.9	18.7
	-5"	21.9	21.7	21.6		19.2
	-6"	21.9	21.6	21.5		19.2
7"-Uninsulated						
	Top Surface	21.3	18.2	17.7		15.1
	-1"	21.3	19.4	19.0		15.9
	-3"	21.3	20.7	20.3		16.7
	-4"	21.3	20.7	20.3		16.8
	-6"	21.3	19.4	19.0		16.0
	Bottom Surface	21.3	18.4	18.1		15.5

* Times are based (in this table) on a 24-hour clock.

TABLE 11

TEST II SLAB TEMPERATURES*

DECEMBER 14

Slab	Time	10:26	11:29
Air		9.4	10.4
6"-1" Urethane			
	Top Surface	10.6	10.7
	-1"	10.9	10.8
	-3"	11.0	10.9
	-5"	11.0	11.0
	-6"	11.0	11.0
6"-1 1/2" Urethane			
	Top Surface	10.8	10.8
	-1"	11.0	10.9
	-3"	11.1	11.0
	-5"	11.1	11.1
	-6"	11.1	11.1
6"-1" Vermiculite			
	Top Surface	9.5	9.6
	-1"	9.4	9.5
	-3"	9.3	9.3
	-5"	9.1	9.2
	-6"	8.9	9.0
6"-Uninsulated			
	Top Surface	10.2	10.3
	-1"	10.2	10.3
	-3"	10.3	10.4
	-5"	10.3	10.4
	Bottom Surface	10.3	10.4
6"-3/4" Urethane			
	Top Surface	10.7	10.8
	-1"	10.8	10.8
	-3"	11.0	10.9
	-5"	11.0	11.0
	-6"	11.0	11.0
7"-Uninsulated			
	Top Surface	10.3	10.3
	-1"	10.3	10.3
	-3"	10.3	10.3
	-4"	10.3	10.4
	-6"	10.2	10.4
	Bottom Surface	10.2	10.4

TABLE 11

TEST II SLAB TEMPERATURES*

DECEMBER 15

Slab	Time	15:37	16:24	19:09	19:38	23:15
Air		4.0	14.7	16.9	15.2	16.8
6"-1" Urethane						
	Top Surface	10.3	11.1	13.2	13.2	14.4
	-1"	10.4	10.6	12.7	12.9	14.1
	-3"	10.4	10.4	12.0	12.4	13.8
	-5"	10.4	10.4	11.8	12.1	13.6
	-6"	10.4	10.4	11.8	12.1	13.6
6"-1 1/2" Urethane						
	Top Surface	10.3	11.2	13.2	13.2	14.3
	-1"	10.4	10.8	12.6	12.8	14.0
	-3"	10.4	10.4	11.9	12.2	13.6
	-5"	10.4	10.4	11.7	12.0	13.5
	-6"	10.4	10.4	11.7	12.0	13.5
6"-1" Vermiculite						
	Top Surface	9.7	10.5	12.0	12.6	13.9
	-1"	9.7	10.1	11.4	12.3	13.6
	-3"	9.6	9.6	11.2	11.7	13.1
	-5"	9.5	9.5	11.2	11.6	13.0
	-6"	9.3	9.5	11.3	11.5	13.0
6"-Uninsulated						
	Top Surface	10.3	11.4	13.9	14.0	15.4
	-1"	10.5	11.0	13.6	13.9	15.2
	-3"	10.5	10.5	13.2	13.6	15.1
	-5"	10.5	10.7	13.3	13.7	15.1
	Bottom Surface	10.3	10.9	13.6	13.8	15.2
6"-3/4" Urethane						
	Top Surface	10.2	11.3	13.3	13.3	14.5
	-1"	10.3	10.8	12.7	12.9	14.2
	-3"	10.3	10.5	12.2	12.6	13.9
	-5"	10.3	10.4	11.9	12.3	13.8
	-6"	10.3	10.4	11.9	12.3	13.8
7"-Uninsulated						
	Top Surface	10.2	11.3	13.7	13.8	15.1
	-1"	10.3	10.8	13.2	13.5	14.9
	-3"	10.3	10.4	12.8	13.2	14.7
	-4"	10.3	10.4	12.8	13.2	14.7
	-6"	10.3	10.7	13.2	13.5	14.9
	Bottom Surface	10.1	11.1	13.7	13.8	15.1

TABLE 11 (Cont'd)

Slab	Time	23:34	23:44
Air		-2.7	-2.4
6"-1" Urethane			
	Top Surface	12.9	11.6
	-1"	14.1	13.2
	-3"	14.1	14.0
	-5"	13.9	13.9
	-6"	13.8	13.8
6"-1 1/2" Urethane			
	Top Surface	12.4	11.4
	-1"	13.8	12.9
	-3"	13.9	13.8
	-5"	13.7	13.7
	-6"	13.7	13.6
6"-1" Vermiculite			
	Top Surface	12.2	11.5
	-1"	13.3	12.6
	-3"	13.4	13.2
	-5"	13.2	12.9
	-6"	12.7	12.2
6"-Uninsulated			
	Top Surface	12.6	12.3
	-1"		13.4
	-3"		14.8
	-5"		14.1
	Bottom Surface		13.2
6"-3/4" Urethane			
	Top Surface		11.8
	-1"		12.9
	-3"		13.9
	-5"		13.8
	-6"		13.7
7"-Uninsulated			
	Top Surface		12.0
	-1"		13.1
	-3"		14.3
	-4"		14.2
	-6"		13.1
	Bottom Surface		11.7

TABLE 11

TEST II SLAB TEMPERATURES*

DECEMBER 16

Slab	Time	00:02	11:33	11:49	12:08	14:30	15:15
Air		-2.5	5.2	4.0	3.2	7.9	9.2
6"-1" Urethane							
	Top Surface	10.9	5.9	5.8	6.2	6.9	7.3
	-1"	12.4	6.0	6.1	6.2	6.8	7.1
	-3"	13.5	6.4	6.4	6.3	6.7	6.8
	-5"	13.8	6.5	6.6	6.4	6.6	6.7
	-6"	13.7	6.5	6.6	6.4	6.5	6.7
6"-1 1/2" Urethane							
	Top Surface	10.8	6.0	5.9	6.3	7.0	7.4
	-1"	12.2	6.2	6.3	6.3	7.0	7.2
	-3"	13.4	6.6	6.7	6.4	6.8	6.9
	-5"	13.6	6.7	6.7	6.4	6.7	6.8
	-6"	13.6	6.7	6.7	6.5	6.6	6.8
6"-1" Vermiculite							
	Top Surface	12.0	5.4	5.2	5.4	6.3	6.7
	-1"	10.9	5.4	5.4	5.4	6.1	6.4
	-3"	12.8	5.5	5.5	5.3	5.9	6.1
	-5"	12.6	5.5	5.5	5.2	5.8	6.0
	-6"	12.0	5.3	5.3	5.2	5.8	6.1
6"-Uninsulated							
	Top Surface	11.5	5.1	4.9	5.2	6.5	7.1
	-1"	12.7	5.1	5.0	5.2	6.5	7.0
	-3"	14.0	5.1	5.2	5.0	6.3	6.7
	-5"	13.5	5.1	5.1	5.1	6.4	6.8
	Bottom Surface	12.5	5.1	5.0	5.1	6.5	7.0
6"-3/4" Urethane							
	Top Surface	11.1	6.1	5.8	6.1	7.0	7.4
	-1"	12.3	6.2	6.0	6.1	6.8	7.1
	-3"	13.4	6.4	6.4	6.2	6.7	6.9
	-5"	13.7	6.5	6.5	6.3	6.[illegible]	6.8
	-6"	13.6	6.5	6.5	6.3	6.6	6.8
7"-Uninsulated							
	Top Surface	11.8	5.2	5.0	5.4	6.4	
	-1"	12.8	5.2	5.1	5.3	6.2	
	-3"	14.0	5.2	5.1	5.1	6.1	
	-4"	13.9	5.2	5.2	5.1	6.1	
	-6"	12.7	5.2	5.1	5.2	6.2	6.8
	Bottom Surface	11.5	5.2	5.0	5.[illegible]	6.4	7.1

TABLE 11 (Cont'd)

Slab	Time	15:22	16:34	22:57	23:10	23:27
Air		1.7	8.5	8.7	-7.9	-6.0
6"-1" Urethane						
	Top Surface	7.3	7.3	7.8	6.2	5.3
	-1"	7.3	7.2	7.7	7.5	6.6
	-3"	7.0	7.1	7.7	7.8	7.4
	-5"	6.9	7.0	7.6	7.8	7.6
	-6"	6.9	7.0	7.6	7.7	7.6
6"-1 1/2" Urethane						
	Top Surface	7.3	7.4	7.8	6.0	5.4
	-1"	7.4	7.2	7.7	7.3	6.5
	-3"	7.0	7.1	7.7	7.7	7.4
	-5"	6.9	7.0	7.6	7.6	7.5
	-6"	6.9	7.0	7.6	7.6	7.5
6"-1" Vermiculite						
	Top Surface	6.6	6.8	7.4	5.9	5.2
	-1"	6.5	6.6	7.3	6.9	6.1
	-3"	6.2	6.4	7.1	7.1	6.8
	-5"	6.1	6.3	7.0	7.0	6.6
	-6"	6.1	6.4	7.0	6.6	6.2
6"-Uninsulated						
	Top Surface	6.8	7.3	7.9	6.0	5.3
	-1"	7.0	7.2	7.9	7.0	6.2
	-3"	6.9	7.1	7.9	7.8	7.2
	-5"	6.9	7.1	7.9	7.5	6.8
	Bottom Surface	6.7	7.2	7.9	6.7	6.1
6"-3/4" Urethane						
	Top Surface	7.1	7.3	7.8	6.1	5.4
	-1"	6.9	7.2	7.7	7.1	6.4
	-3"	6.8	7.0	7.6	7.5	7.3
	-5"	6.8	7.0	7.6	7.5	7.5
	-6"	6.8	7.0	7.6	7.4	7.4
7"-Uninsulated						
	Top Surface	6.7	7.1	7.8	6.2	5.6
	-1"	6.7	7.0	7.7	6.9	6.3
	-3"	6.4	6.8	7.7	7.5	7.2
	-4"	6.5	6.9	7.7	7.5	7.1
	-6"	6.8	7.1	7.8	7.0	6.3
	Bottom Surface	6.8	7.2	7.9	6.0	5.3

TABLE 11

TEST II SLAB TEMPERATURES*

DECEMBER 17

Slab	Time	08:16	08:28	08:59	09:20	09:40
Air		0.8	-3.6	0.5	2.5	3.2
6"-1" Urethane						
	Top Surface	1.6	1.6	1.5	1.8	2.0
	-1"	1.8	2.0	1.7	1.8	2.0
	-3"	2.1	2.3	2.0	2.0	1.9
	-5"	2.3	2.4	2.1	2.1	2.0
	-6"	2.3	2.4	2.1	2.1	2.0
6"-1 1/2" Urethane						
	Top Surface	1.8	1.7	1.7	2.1	2.2
	-1"	2.0	2.2	1.9	2.1	2.1
	-3"	2.4	2.5	2.3	2.1	2.1
	-5"	2.5	2.5	2.3	2.2	2.1
	-6"	2.5	2.5	2.3	2.2	2.1
6"-1" Vermiculite						
	Top Surface	1.3	1.3	1.2	1.4	1.6
	-1"	1.4	1.5	1.2	1.3	1.4
	-3"	1.5	1.6	1.3	1.3	1.3
	-5"	1.5	1.6	1.3	1.3	1.3
	-6"	1.5	1.5	1.3	1.3	1.3
6"-Uninsulated						
	Top Surface	1.4	0.6	0.6	1.0	1.3
	-1"	1.4	0.8	0.7	0.9	1.1
	-3"	1.4	0.9	0.8	0.8	0.9
	-5"	1.4	0.9	0.8	0.8	1.0
	Bottom Surface	1.4	0.7	0.7	0.9	1.1
6"-3/4" Urethane						
	Top Surface	1.8	1.6	1.6	1.9	2.1
	-1"	1.9	1.9	1.7	1.9	2.0
	-3"	2.2	2.2	2.0	2.0	1.9
	-5"	2.3	2.3	2.1	2.0	1.9
	-6"	2.3	2.3	2.1	2.0	2.0
7"-Uninsulated						
	Top Surface	1.0	0.8	0.8	1.1	1.3
	-1"	1.0	0.9	0.8	1.0	1.0
	-3"	1.0	0.9	0.8	0.8	0.8
	-4"	0.9	0.9	0.8	0.8	0.9
	-6"	0.9	0.8	0.7	1.0	1.1
	Bottom Surface	0.9	0.7	0.7	1.1	1.3

TABLE 11 (Cont'd)

Slab	Time	15:41	21:47	22:21
Air		4.4	4.0	-5.4
6"-1" Urethane				
	Top Surface	3.0	3.2	2.4
	-1"	2.9	3.3	3.0
	-3"	2.8	3.3	3.3
	-5"	2.8	3.2	3.3
	-6"	2.8	3.2	3.3
6"-1 1/2" Urethane				
	Top Surface	3.1	3.4	2.4
	-1"	3.0	3.3	3.0
	-3"	2.9	3.2	3.2
	-5"	2.8	3.2	3.2
	-6"	2.8	3.2	3.2
6"-1" Vermiculite				
	Top Surface	2.8	3.1	2.4
	-1"	2.6	3.0	2.8
	-3"	2.5	2.9	2.9
	-5"	2.4	2.9	2.9
	-6"	2.5	2.9	2.7
6"-Uninsulated				
	Top Surface	3.1	3.4	2.4
	-1"	3.1	3.4	2.9
	-3"	3.0	3.4	3.4
	-5"	2.9	3.4	3.2
	Bottom Surface	2.9	3.4	2.7
6"-3/4" Urethane				
	Top Surface	3.0	3.3	2.3
	-1"	3.1	3.2	2.8
	-3"	2.9	3.2	3.1
	-5"	2.8	3.2	3.1
	-6"	2.8	3.2	3.1
7"-Uninsulated				
	Top Surface	3.0	3.3	2.4
	-1"	2.8	3.2	2.8
	-3"	2.6	3.2	3.1
	-4"	2.7	3.2	3.2
	-6"	2.8	3.3	2.8
	Bottom Surface	3.0	3.4	2.3

TABLE 11

TEST II SLAB TEMPERATURES

DECEMBER 18

Slab	Time	08:37	08:44	08:58	09:05	11:31
Air		1.2	-4.7	-0.1	4.1	2.1
6"-1" Urethane						
	Top Surface	1.2	1.2	1.0	1.2	1.3
	-1"	1.3	1.5	1.2	1.3	1.3
	-3"	1.4	1.5	1.4	1.4	1.3
	-5"	1.4	1.5	1.4	1.5	1.3
	-6"	1.4	1.5	1.4	1.5	1.3
6"-1 1/2" Urethane						
	Top Surface	1.4	1.1	1.2	1.4	1.4
	-1"	1.4	1.5	1.3	1.4	1.3
	-3"	1.5	1.6	1.5	1.5	1.3
	-5"	1.5	1.6	1.5	1.6	1.3
	-6"	1.5	1.6	1.5	1.6	1.3
6"-1" Vermiculite						
	Top Surface	1.1	1.0	0.9	1.0	1.2
	-1"	1.1	1.2	1.0	1.0	1.1
	-3"	1.1	1.2	1.1	1.1	1.0
	-5"	1.1	1.2	1.1	1.1	1.0
	-6"	1.1	1.1	1.0	1.1	1.0
6"-Uninsulated						
	Top Surface	1.1	0.8	0.9	1.1	1.2
	-1"	1.1	1.1	0.9	1.1	1.2
	-3"	1.1	1.2	1.1	1.1	1.2
	-5"	1.1	1.2	1.0	1.1	1.2
	Bottom Surface	1.1	1.0	1.0	1.1	1.2
6"-3/4" Urethane						
	Top Surface	1.3	1.0	1.1	1.3	1.4
	-1"	1.3	1.3	1.2	1.3	1.4
	-3"	1.4	1.4	1.4	1.4	1.3
	-5"	1.4	1.5	1.4	1.5	1.3
	-6"	1.4	1.5	1.4	1.5	1.3
7"-Uninsulated						
	Top Surface	1.1	0.9	0.9	1.1	1.1
	-1"	1.0	1.0	0.9	1.0	1.1
	-3"	1.1	1.0	1.0	1.0	1.0
	-4"	1.1	1.1	1.0	1.0	1.0
	-6"	1.1	1.0	0.9	1.0	1.1
	Bottom Surface	1.1	0.8	0.9	1.0	1.2

TABLE 11 (Cont'd)

Slab	Time	11:52	14:39	14:58	23:30
Air		2.3	2.0	-0.7	0.7
6"-1" Urethane					
	Top Surface	1.7	0.8	0.7	0.2
	-1"	1.6	0.9	1.1	0.3
	-3"	1.4	1.0	1.1	0.5
	-5"	1.3	1.1	1.2	0.5
	-6"	1.3	1.1	1.2	0.6
6"-1 1/2" Urethane					
	Top Surface	2.2	1.0	0.9	0.4
	-1"	1.8	1.0	1.1	0.4
	-3"	1.3	1.1	1.1	0.5
	-5"	1.3	1.2	1.1	0.5
	-6"	1.3	1.2	1.1	0.5
6"-1" Vermiculite					
	Top Surface	2.0	0.9	0.7	0.4
	-1"	1.5	0.9	0.8	0.4
	-3"	1.0	0.9	0.9	0.4
	-5"	1.0	1.0	0.9	0.4
	-6"	1.0	1.1	0.9	0.5
6"-Uninsulated					
	Top Surface	2.0	0.9	0.7	0.4
	-1"	1.8	1.0	0.8	0.5
	-3"	1.1	1.0	1.0	0.6
	-5"	1.1	1.1	1.1	0.7
	Bottom Surface	1.2	1.2	1.1	0.7
6"-3/4" Urethane					
	Top Surface	1.9	1.0	0.8	0.4
	-1"	1.7	1.0	0.9	0.4
	-3"	1.3	1.1	1.0	0.5
	-5"	1.3	1.2	1.1	0.6
	-6"	1.3	1.2	1.1	0.6
7"-Uninsulated					
	Top Surface	1.7	0.8	0.7	0.4
	-1"	1.6	0.8	0.8	0.4
	-3"	1.1	0.9	0.9	0.5
	-4"	1.0	1.0	0.9	0.6
	-6"	1.1	1.1	1.0	0.7
	Bottom Surface	1.3	1.2	1.1	0.7

TABLE 11

TEST II SLAB TEMPERATURES

DECEMBER 19

Slab	Time	00:06	00:19	00:35	00:53	01:12
Air		1.6	-7.6	-5.7	-5.0	-5.0
6"-1" Urethane						
	Top Surface	0.3	0.1	-0.2	-0.2	-0.2
	-1"	0.4	0.5	0.3	0.2	0.1
	-3"	0.5	0.6	0.6	0.4	0.4
	-5"	0.5	0.6	0.7	0.5	0.5
	-6"	0.5	0.6	0.7	0.5	0.5
6"-1 1/2" Urethane						
	Top Surface	0.5	0.1	0.0	-0.1	-0.2
	-1"	0.5	0.6	0.4	0.3	0.2
	-3"	0.5	0.6	0.6	0.5	0.4
	-5"	0.5	0.6	0.6	0.5	0.4
	-6"	0.5	0.6	0.6	0.5	0.4
6"-1" Vermiculite						
	Top Surface	0.5	0.1	-0.1	-0.2	-0.3
	-1"	0.4	0.5	0.3	0.1	0.0
	-3"	0.5	0.5	0.5	0.4	0.3
	-5"	0.5	0.5	0.5	0.4	0.3
	-6"	0.6	0.6	0.5	0.4	0.3
6"-Uninsulated						
	Top Surface	0.6	0.0	-0.1	-0.2	-0.3
	-1"	0.5	0.4	0.2	0.1	0.0
	-3"	0.6	0.7	0.6	0.5	0.3
	-5"	0.7	0.7	0.6	0.5	0.3
	Bottom Surface	0.8	0.4	0.4	0.3	0.1
6"-3/4" Urethane						
	Top Surface	0.5	-0.1	-0.2	-0.2	-0.3
	-1"	0.5	0.4	0.2	0.0	0.0
	-3"	0.5	0.5	0.4	0.4	0.3
	-5"	0.6	0.5	0.6	0.6	0.4
	-6"	0.6	0.5	0.6	0.6	0.4
7"-Uninsulated						
	Top Surface	0.5	0.0	-0.1	-0.2	-0.2
	-1"	0.5	0.4	0.2	0.2	0.0
	-3"	0.6	0.5	0.5	0.4	0.2
	-4"	0.6	0.6	0.5	0.4	0.2
	-6"	0.7	0.6	0.4	0.3	0.2
	Bottom Surface	0.8	0.2	0.1	0.1	0.1

TABLE 11 (Cont'd)

Slab	Time	01:31	01:47	02:08	02:18	02:28
Air		-5.4	-5.6	-5.5	-0.1	-1.6
6"-1" Urethane						
	Top Surface	-0.1	-0.2	-0.1	-0.2	-0.2
	-1"	0.1	0.1	0.0	0.0	0.0
	-3"	0.3	0.2	0.2	0.1	0.1
	-5"	0.4	0.3	0.3	0.2	0.2
	-6"	0.4	0.3	0.3	0.2	0.2
6"-1 1/2" Urethane						
	Top Surface	-0.2	-0.2	-0.1	-0.1	-0.1
	-1"	0.1	0.0	0.0	0.0	0.0
	-3"	0.4	0.2	0.2	0.1	0.1
	-5"	0.4	0.2	0.2	0.2	0.2
	-6"	0.4	0.2	0.2	0.2	0.2
6"-1" Vermiculite						
	Top Surface	-0.3	-0.4	-0.4	-0.3	-0.5
	-1"	-0.1	-0.2	-0.2	-0.3	-0.3
	-3"	0.2	0.1	0.0	-0.1	-0.1
	-5"	0.2	0.1	0.0	-0.1	-0.1
	-6"	0.2	0.1	0.1	0.0	-0.1
6"-Uninsulated						
	Top Surface	-0.4	-0.5	-0.3	-0.2	-0.1
	-1"	-0.1	-0.2	-0.2	-0.1	-0.1
	-3"	0.2	0.1	0.0	-0.1	-0.1
	-5"	0.2	0.1	0.0	-0.1	-0.1
	Bottom Surface	0.0	-0.1	-0.2	-0.1	-0.2
6"-3/4" Urethane						
	Top Surface	-0.4	-0.5	-0.2	-0.1	-0.1
	-1"	-0.1	-0.2	-0.2	-0.1	-0.1
	-3"	0.1	0.1	0.0	0.1	0.0
	-5"	0.4	0.3	0.2	0.2	0.2
	-6"	0.4	0.3	0.2	0.2	0.2
7"-Uninsulated						
	Top Surface	-0.3	-0.5	-0.5	-0.3	-0.5
	-1"	-0.1	-0.2	-0.2	-0.3	-0.4
	-3"	0.1	0.0	-0.1	-0.1	-0.2
	-4"	0.1	0.0	-0.1	-0.1	-0.2
	-6"	0.1	0.0	-0.1	-0.1	-0.2
	Bottom Surface	-0.1	-0.3	-0.3	-0.1	-0.3

TABLE 11 (Cont'd)

Slab	Time	02:46	03:08	03:29	03:47	04:10
Air		-5.4	-5.5	-5.5	-5.4	-5.5
6"-1" Urethane						
	Top Surface	-0.1	-0.2	-0.2	-0.2	-0.1
	-1"	0.0	0.0	0.0	0.0	0.0
	-3"	0.1	0.0	0.0	0.0	0.1
	-5"	0.2	0.1	0.1	0.1	0.1
	-6"	0.2	0.1	0.1	0.1	0.1
6"-1 1/2" Urethane						
	Top Surface	-0.1	-0.1	-0.1	-0.1	0.0
	-1"	0.0	0.0	-0.1	-0.1	0.0
	-3"	0.1	0.0	0.0	0.0	0.0
	-5"	0.1	0.0	0.0	0.0	0.0
	-6"	0.1	0.0	0.0	0.0	0.0
6"-1" Vermiculite						
	Top Surface	-0.5	-0.4	-0.2	-0.2	-0.1
	-1"	-0.2	-0.2	-0.2	-0.2	-0.1
	-3"	-0.1	-0.2	-0.2	-0.2	-0.1
	-5"	-0.1	-0.2	-0.2	-0.2	-0.1
	-6"	-0.1	-0.2	-0.2	-0.2	-0.1
6"-Uninsulated						
	Top Surface	-0.1	-0.2	-0.2	-0.2	-0.2
	-1"	-0.1	-0.2	-0.2	-0.2	-0.1
	-3"	-0.1	-0.2	-0.2	-0.2	-0.1
	-5"	-0.1	-0.2	-0.2	-0.2	-0.2
	Bottom Surface	-0.3	-0.4	-0.4	-0.4	-0.4
6"-3/4" Urethane						
	Top Surface	-0.2	-0.2	-0.2	-0.2	-0.1
	-1"	-0.2	-0.2	-0.2	-0.2	-0.1
	-3"	0.0	-0.1	-0.1	-0.1	0.0
	-5"	0.1	0.0	0.0	0.0	0.0
	-6"	0.1	0.0	0.0	0.0	0.0
7"-Uninsulated						
	Top Surface	-0.4	-0.3	-0.2	-0.2	-0.1
	-1"	-0.3	-0.3	-0.3	-0.3	-0.2
	-3"	-0.3	-0.3	-0.3	-0.4	-0.3
	-4"	-0.3	-0.3	-0.4	-0.4	-0.3
	-6"	-0.3	-0.4	-0.4	-0.5	-0.4
	Bottom Surface	-0.5	-0.6	-0.6	-0.6	-0.6

TABLE 11 (Cont'd)

Slab	Time	04:31	04:54	05:08	13:40	14:08
Air		-4.5	-5.4	-0.1	-5.3	-1.2
6"-1' Urethane						
	Top Surface	-0.2	-0.2	-0.3	-1.0	-1.2
	-1"	-0.1	-0.1	-0.2	-0.8	-1.0
	-3"	0.0	-0.1	-0.1	-0.8	-0.9
	-5"	0.0	0.0	-0.1	-0.7	-0.8
	-6"	0.0	0.0	-0.1	-0.7	-0.8
6"-1 1/2' Urethane						
	Top Surface	-0.1	-0.1	-0.2	-1.0	-1.0
	-1"	0.0	-0.1	-0.1	-0.7	-0.9
	-3"	0.0	-0.1	-0.1	-0.7	-0.7
	-5"	0.0	-0.1	-0.1	-0.7	-0.7
	-6"	0.0	[illegible]	-0.1	-0.7	-0.7
6"-1' Vermiculite						
	Top Surface	-0.1	-0.2	-0.2	-0.9	-1.0
	-1"	-0.2	-0.2	-0.3	-0.8	-0.9
	-3"	-0.2	-0.2	-0.3	-0.7	-0.8
	-5"	-0.2	-0.3	-0.3	-0.7	-0.8
	-6"	-0.2	-0.3	-0.3	-0.7	-0.8
6"-Uninsulated						
	Top Surface	-0.2	-0.3	-0.3	-1.0	-1.0
	-1'	-0.2	-0.3	-0.3	-0.8	-0.9
	-3'	-0.2	-0.3	-0.3	-0.8	-0.8
	-5"	-0.2	-0.3	-0.3	-0.7	-0.8
	Bottom Surface	-0.4	-0.5	-0.3	-0.8	-0.8
6"-3/4" Urethane						
	Top Surface	-0.1	-0.2	-0.1	-1.0	-1.0
	-1"	-0.1	-0.2	-0.2	-0.8	-0.9
	-3"	-0.1	-0.2	-0.1	-0.7	-0.8
	-5"	0.0	-0.1	-0.1	-0.7	-0.7
	-6"	0.0	-0.1	-0.1	-0.7	-0.7
7"-Uninsulated						
	Top Surface	-0.2	-0.3	-0.2	1.0	-1.0
	-1"	-0.2	-0.3	-0.3	0.9	-0.9
	-3"	-0.3	-0.4	-0.4	0.8	-0.8
	-4"	-0.4	-0.5	-0.4	0.8	-0.8
	-6"	-0.5	-0.5	-0.5	0.7	-0.8
	Bottom Surface	-0.6	-0.7	-0.4	0.9	-0.8

TABLE 12

TEST III SLAB TEMPERATURES*

Slab	Time	0	7	14	24	32	[illegible]
Air		[illegible]	[illegible]	7.5	9.4	10.6	[illegible]
6"-1" Urethane							
	Top Surface	[illegible]	-1.1	-0.6	-0.3	-0.2	0.0
	-1"	-1.5	-1.6	-1.2	-0.8	-0.7	-0.5
	-3"	[illegible]	-1.6	-1.4	[illegible]	-1.2	-1.1
	-5"	-1.5	-1.6	-1.4	[illegible]	-1.3	-1.3
	-6"	-1.5	[illegible]	-1.4	[illegible]	-1.3	-1.2
6"-1 1/2" Urethane							
	Top Surface	-1.5	[illegible]	-0.2	[illegible]	0.0	0.3
	-1"	-1.5	[illegible]	-1.0	-0.6	-0.5	-0.3
	-3"	-1.5	[illegible]	-1.6	[illegible]	-1.2	-1.1
	-5"	-1.5	[illegible]	-1.7	-1.5	-1.4	-1.3
	-6"	-1.5	[illegible]	-1.8	[illegible]	-1.4	-1.3
6"-1" Vermiculite							
	Top Surface	-1.5	-1.2	-0.9	[illegible]	-0.3	-0.1
	-1"	[illegible]	-1.6	-1.4	-1.0	-0.8	-0.5
	-3"	[illegible]	-1.7	-1.7	-1.4	-1.2	-1.0
	-5"	-1.5	-1.7	-1.6	-1.3	-1.1	-0.8
	-6"	[illegible]	[illegible]	-1.3	-0.9	-0.6	[illegible]
6"-Uninsulated							
	Top Surface	[illegible]	[illegible]	-0.7	-0.4	-0.2	-0.1
	-1"	-1.5	-1.4	-1.1	-0.7	-0.5	-0.3
	-3"	[illegible]	-1.6	-1.5	-1.1	-0.9	-0.5
	-5"	[illegible]	-1.4	-1.0	-0.4	0.0	0.5
	Bottom Surface	[illegible]	[illegible]	-0.3	0.5	0.9	1.4
6"-3/4" Urethane							
	Top Surface	[illegible]	-0.9	-0.5	-0.2	-0.1	0.0
	-1"	[illegible]	-1.5	-1.2	-0.9	-0.7	-0.5
	-3"	-1.6	-1.7	-1.6	-1.4	-1.2	-1.0
	-5"	-1.5	-1.6	-1.5	-1.4	-1.2	-1.2
	-6"	-1.6	[illegible]	-1.4	-1.3	-1.2	-1.1
7"-Uninsulated							
	Top Surface	-1.5	-0.9	-0.5	-0.2	-0.1	0.0
	-1"	-1.6	-1.4	-1.1	-0.7	-0.5	-0.3
	-3"	-1.6	-1.8	-1.7	-1.3	-1.1	-0.8
	-4"	-1.6	-1.8	-1.7	-1.3	-1.0	-0.6
	-6"	-1.5	-1.3	-0.9	-0.2	0.1	0.7
	Bottom Surface	-1.5	-0.3	0.4	1.1	1.6	22.2

TABLE 12 (Cont'd)

Slab	Time	49	58	63	97
Air		[illegible]	[illegible]	[illegible]	[illegible]
6"-1" Urethane					
	Top Surface	1.0	1.8	[illegible]	[illegible]
	1"	-0.2	[illegible]	[illegible]	[illegible]
	-3"	-1.0	[illegible]	-0.7	[illegible]
	-5"	[illegible]	[illegible]	-1.0	[illegible]
	-6"	[illegible]	[illegible]	[illegible]	[illegible]
5"-1 1/2" Urethane					
	Top Surface	[illegible]	1.0	[illegible]	[illegible]
	[illegible]	-0.1	[illegible]	[illegible]	[illegible]
	[illegible]	-1.1	[illegible]	[illegible]	[illegible]
	[illegible]	-1.2	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	-0.8
5"-1" [illegible]					
	Top Surface	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	-3"	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5"-Uninsulated					
	Top Surface	[illegible]	[illegible]	[illegible]	[illegible]
	-1"	[illegible]	0.0	[illegible]	2.2
	-3"	[illegible]	[illegible]	[illegible]	[illegible]
	-5"	[illegible]	[illegible]	[illegible]	2.8
	Bottom Surface	[illegible]	[illegible]	[illegible]	[illegible]
6"-3/4" Urethane					
	Top Surface	0.2	1	[illegible]	5.5
	-1"	-0.5	[illegible]	[illegible]	2.0
	-3"	[illegible]	[illegible]	[illegible]	0.4
	[illegible]	-1.1	-0.9	-0.8	[illegible]
	-6"	[illegible]	[illegible]	[illegible]	[illegible]
7"-Uninsulated					
	Top Surface	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	-0.2	[illegible]	0.3	[illegible]
	[illegible]	-0.5	[illegible]	-0.2	[illegible]
	[illegible]	-0.4	0.3	0.2	[illegible]
	-6"	1.0	1.5	1.8	[illegible]
	Bottom Surface	2.6	3.1	3.4	5.0

TABLE 13

[illegible] SLAB TEMPERATURES*

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]								
Top surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.4
[illegible]								
Top surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.4
[illegible]								
Top surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.6
[illegible]								
Top surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.5
Bottom surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.9
[illegible]								
Top surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.2
[illegible]								
Top surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-4	[illegible]	[illegible]	[illegible]	[illegible]	5.3	[illegible]	5.2	4.9
-5	[illegible]	6.8	[illegible]	[illegible]	5.3	[illegible]	4.5	4.2
Bottom surface	7.4	5.5	[illegible]	4.8	4.5	[illegible]	3.5	3.4

Table 13 (Cont'd)

[illegible]	228	230	[illegible]	[illegible]	231	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Chains							
Top Surface	0.5	0.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.[illegible]	[illegible]
[illegible] Chains							
Top Surface	0.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
Top Surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].8
[illegible]	[illegible]	[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
Top Surface	[illegible]	[illegible]	[illegible]	0.3	[illegible]	[illegible]	[illegible]
[illegible]	0.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.[illegible]
[illegible]	1.[illegible]	[illegible]	0.[illegible]	[illegible].3	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.[illegible]
Bottom Surface	0.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]							
Top Surface	[illegible]	[illegible]	[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.[illegible]	1	0.[illegible]	[illegible]	0.7	[illegible]	[illegible]
[illegible]	2	[illegible]	[illegible]	1.[illegible]	1.[illegible]	[illegible]	1.4
[illegible]	[illegible]	[illegible]	2.[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible].9
[illegible]	2.[illegible]	[illegible]	2.[illegible]	2.2	2.[illegible]	[illegible]	1.9
[illegible]							
Top Surface	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-2"	[illegible]	0.4	[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.[illegible]	0.5	0.[illegible]	[illegible]	[illegible]	[illegible]	0.3
-5"	1.0	0.[illegible]	0.[illegible]	0.5	0.5	[illegible]	[illegible]
-6"	[illegible]	0.5	0.[illegible]	0.4	0.3	[illegible]	[illegible]
Bottom Surface	0.[illegible]	0.3	[illegible]	0.2	0.3	[illegible]	0.2

TABLE 13 (Cont'd)

Slab	Time	282	288	296	305	315	323	333
Air		-0.8	-1.8	-2.3	-2.6	-2.3	-4.6	-2.7
6"-1" Urethane								
	Top Surface	0.1	0.0	-0.1	-0.2	-0.3	-0.2	-0.3
	-1"	0.7	0.7	0.6	0.5	0.5	0.5	0.4
	-3"	1.6	1.5	1.4	1.4	1.2	1.2	1.0
	-5"	2.1	2.0	1.9	1.8	1.6	1.6	1.4
	-6"	2.1	2.0	1.9	1.8	1.6	1.6	1.4
6"-1 1/2" Urethane								
	Top Surface	0.3	0.2	0.1	0.0	-0.1	-0.1	-0.2
	-1"	0.9	0.8	0.7	0.6	0.5	0.5	0.4
	-3"	1.8	1.7	1.6	1.5	1.4	1.3	1.2
	-5"	2.2	2.1	1.9	1.9	1.7	1.6	1.5
	-6"	2.2	2.1	1.9	1.9	1.7	1.6	1.5
6"-1" Vermiculite								
	Top Surface	0.3	0.2	0.1	0.0	-0.1	-0.1	-0.2
	-1"	0.8	0.7	0.6	0.5	0.4	0.4	0.2
	-3"	1.5	1.4	1.3	1.2	1.1	1.0	0.9
	-5"	1.7	1.6	1.4	1.4	1.2	1.2	1.0
	-6"	1.7	1.5	1.4	1.3	1.2	1.1	1.0
6"-Uninsulated								
	Top Surface	-0.1	-0.2	-0.3	-0.4	-0.3	-0.2	-0.2
	-1"	0.1	0.0	-0.1	-0.2	-0.1	-0.1	-0.1
	-3"	0.4	0.3	0.2	0.2	0.1	0.0	-0.1
	-5"	0.3	0.2	0.1	0.0	0.0	-0.1	-0.2
	Bottom Surface	0.1	0.0	-0.1	-0.2	-0.2	-0.4	-0.4
6"-3/4" Urethane								
	Top Surface	0.2	0.0	0.0	-0.1	-0.1	-0.1	-0.1
	-1"	0.6	0.5	0.4	0.4	0.4	0.3	0.3
	-3"	1.3	1.3	1.1	1.1	1.0	1.0	0.[illegible]
	-5"	1.8	1.7	1.6	1.5	1.4	1.3	1.2
	-6"	1.8	1.7	1.6	1.5	1.4	1.3	1.2
7"-Uninsulated								
	Top Surface	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1
	-1"	-0.1	-0.1	-0.1	-0.1	0.0	-0.1	-0.1
	-3"	0.2	0.2	0.1	0.0	0.0	-0.1	-0.1
	-4"	0.2	0.1	0.0	0.0	0.0	-0.[illegible]	-0.2
	-6"	0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4
	Bottom Surface	0.0	-0.2	-0.3	-0.4	-0.4	-0.6	-0.6

TABLE 13 (Cont'd)

[illegible]	[illegible]	459	469
[illegible]	[illegible]	[illegible]	[illegible]

TABLE 14

TEST V SLAB TEMPERATURES*

Slab	Time	0	6	16	38	56	74	93	102
Air		8.6	-5.8	-9.2	-11.6	-11.5	-11.5	-9.6	-10.2
6"-1" Urethane									
	Top Surface	8.7	6.9	4.9	2.2	1.2	0.9	0.6	0.6
	-1"	9.2	8.9	7.7	5.2	4.0	3.2	2.7	2.5
	-3"	9.2	9.3	9.2	8.0	6.9	5.9	5.1	4.8
	-5"	9.2	9.4	9.4	8.9	8.3	7.5	6.6	6.1
	-6"	9.2	9.3	9.3	8.8	8.3	7.5	6.7	6.2
6"-1 1/2" Urethane									
	Top Surface	8.7	6.9	4.9	2.2	1.3	0.6	0.4	0.4
	-1"	9.2	8.7	7.5	5.0	3.8	2.9	2.3	2.2
	-3"	9.3	9.3	9.2	8.2	7.3	6.4	5.5	5.1
	-5"	9.3	9.2	9.3	8.9	8.3	7.5	6.7	6.3
	-6"	9.2	9.2	9.2	8.9	8.4	7.6	6.8	6.4
6"-1" Vermiculite									
	Top Surface	8.9	7.1	5.2	2.8	1.8	0.9	0.5	0.3
	-1"	9.2	8.7	7.6	5.2	4.0	3.0	2.3	2.0
	-3"	9.3	9.2	9.2	8.1	7.0	5.9	4.9	4.5
	-5"	9.3	9.2	9.1	8.2	7.3	6.3	5.3	4.9
	-6"	9.2	8.9	8.2	7.4	6.6	5.8	4.8	4.4
6"-Uninsulated									
	Top Surface	8.9	7.3	5.6	3.3	2.2	0.9	0.3	0.3
	-1"	9.1	8.4	7.1	4.9	3.5	2.3	1.2	1.0
	-3"	9.3	9.3	9.0	7.2	5.8	4.3	3.0	2.4
	-5"	9.2	8.9	8.1	6.1	4.8	3.5	2.2	1.7
	Bottom Surface	9.2	7.8	6.5	4.5	3.3	2.0	1.0	0.5
6"-3/4" Urethane									
	Top Surface	8.7	6.5	4.6	2.1	1.1	0.6	0.7	0.6
	-1"	9.0	8.3	7.1	4.8	3.6	2.7	2.3	2.2
	-3"	9.3	9.1	9.0	7.8	6.6	5.6	4.8	4.5
	-5"	9.3	9.2	9.2	8.7	7.9	7.1	5.8	5.7
	-6"	9.2	9.0	9.0	8.6	7.9	7.0	6.1	5.7
7"-Uninsulated									
	Top Surface	8.8	6.6	5.1	2.9	1.8	0.8	0.4	0.4
	-1"	9.0	8.2	6.9	4.7	3.4	2.3	1.4	1.2
	-3"	9.2	9.1	8.9	7.4	6.0	4.6	3.4	2.8
	-4"	9.2	9.1	8.9	7.5	6.0	4.6	3.4	2.8
	-6"	9.1	8.6	7.6	5.6	4.2	3.0	1.8	1.3
	Bottom Surface	9.2	7.0	5.5	3.5	2.2	1.1	0.3	-0.2

TABLE 14 (Cont'd)

Slab	Time	109	126	136	143	155	162	171
Air		-10.1	-9.8	-10.9	-12.2	-9.6	-8.8	-12.0
6"-1" Urethane								
	Top Surface	0.5	0.3	0.3	0.1	-0.3	-1.1	1.6
	-1"	2.3	2.0	1.8	1.6	1.2	0.7	0.3
	-3"	4.6	4.0	3.7	3.4	3.1	2.8	2.5
	-5"	5.9	5.2	4.9	4.6	4.2	3.8	3.6
	-6"	5.9	5.3	4.9	4.6	4.3	3.9	3.6
6"-1 1/2" Urethane								
	Top Surface	0.4	0.3	0.2	0.1	0.1	-0.2	-0.6
	-1"	2.0	1.7	1.6	1.5	1.3	1.1	0.9
	-3"	4.9	4.3	4.0	3.8	3.5	3.2	3.0
	-5"	6.0	5.3	5.0	4.7	4.4	4.1	3.8
	-6"	6.1	5.4	5.0	4.7	4.4	4.1	3.8
6"-1" Vermiculite								
	Top Surface	0.4	0.3	0.2	0.2	0.1	0.0	-0.2
	-1"	1.9	1.5	1.4	1.2	1.1	0.9	0.8
	-3"	4.1	3.5	3.1	2.9	2.6	2.3	2.1
	-5"	4.6	3.8	3.4	3.1	2.8	2.5	2.2
	-6"	4.1	3.4	3.0	2.7	2.3	2.0	1.8
6"-Uninsulated								
	Top Surface	0.2	0.1	0.0	-0.1	-0.5	-1.1	-1.5
	-1"	0.8	0.5	0.3	0.2	-0.1	-0.5	-0.8
	-3"	2.1	1.2	0.8	0.5	0.2	-0.1	-0.4
	-5"	1.3	0.4	-0.1	-0.4	-0.7	-1.0	-1.3
	Bottom Surface	0.2	-0.7	-1.1	-1.4	-1.7	-1.9	-2.2
6"-3/4" Urethane								
	Top Surface	0.6	0.3	0.3	0.2	-0.1	-0.6	-1.4
	-1"	2.0	1.6	1.4	1.2	0.9	0.6	0.1
	-3"	4.2	3.6	3.3	3.0	2.7	2.3	2.7
	-5"	5.5	4.7	4.3	4.0	3.6	3.3	3.0
	-6"	5.5	4.7	4.3	4.0	3.6	3.3	3.0
7"-Uninsulated								
	Top Surface	0.3	0.1	0.0	0.0	-0.2	-0.8	-1.5
	-1"	1.1	0.7	0.5	0.4	0.2	-0.2	-0.7
	-3"	2.5	1.7	1.2	1.0	0.6	0.3	0.0
	-4"	2.4	1.5	0.9	0.7	0.2	-0.7	-0.4
	-6"	1.0	0.1	-0.4	-0.7	-1.1	-1.4	-1.7
	Bottom Surface	-0.5	-1.4	-1.8	-2.0	-2.4	-2.5	-2.9

TABLE 15

TEST VI SLAB TEMPERATURES

Slab	Time	0	18	23	30	37	43	49
Air		9.6	-12.3	-12.0	-10.8	-11.0	-8.6	-8.1
6"-1" Urethane								
	Top Surface	-9.5	-9.4	-2.6	-1.9	-4.7	-6.0	-6.8
	-1"	-9.4	-9.3	-8.8	-6.2	-5.9	-6.4	-6.7
	-3"	-9.4	-9.3	-9.2	-9.0	-8.5	-8.2	-7.9
	-5"	-9.4	-9.3	-9.2	-9.2	-9.2	-9.1	-9.0
	-6"	-9.4	-9.3	-9.2	-9.2	-9.2	-9.2	-9.1
6"-1 1/2" Urethane								
	Top Surface	-9.4	-9.4	-1.3	-0.8	-4.5	-5.9	-6.7
	-1"	-9.4	-9.2	-8.0	-5.3	-5.1	-5.9	-6.4
	-3"	-9.4	-9.3	-9.2	-9.0	-8.6	-8.3	-8.0
	-5"	-9.4	-9.3	-9.2	-9.2	-9.2	-9.1	-8.9
	-6"	-9.4	-9.3	-9.3	-9.3	-9.3	-9.2	-9.0
6"-1" Vermiculite								
	Top Surface	-9.3	-9.3	-2.4	-3.3	-5.0	-5.9	-6.5
	-1"	-9.3	-9.3	-8.0	-5.5	-5.4	-5.8	-6.2
	-3"	-9.3	-9.2	-9.2	-9.0	-8.6	-8.3	-8.0
	-5"	-9.3	-9.2	-9.2	-9.2	-9.2	-9.0	-8.8
	-6"	-9.3	-9.2	-9.2	-9.2	-9.2	-9.2	-9.0
6"-Uninsulated								
	Top Surface	-9.3	-9.3	-1.2	-1.3	-4.7	-5.5	-6.1
	-1"	-9.3	-9.2	-6.3	-4.1	-4.9	-5.6	-6.0
	-3"	-9.3	-9.2	-9.2	-8.8	-8.2	-7.8	-7.6
	-5"	-9.3	-9.2	-9.2	-9.2	-9.1	-9.0	-8.7
	Bottom Surface	-9.3	-9.3	-9.3	-9.3	-9.3	-9.0	-8.9
6"-3/4" Urethane								
	Top Surface	-9.3	-9.4	-2.3	-1.5	-4.8	-5.9	-6.6
	-1"	-9.4	-9.4	-8.3	-5.9	-5.6	-6.1	-6.6
	-3"	-9.4	-9.3	-9.3	-8.9	-8.5	-8.0	-7.9
	-5"	-9.4	-9.3	-9.3	-9.2	-9.2	-9.1	-8.8
	-6"	-9.4	-9.3	-9.3	-9.3	-9.3	-9.1	-9.0
7"-Uninsulated								
	Top Surface	-9.3	-9.4	-1.3	-0.9	-3.7	-5.2	-6.1
	-1"	-9.4	-9.4	-6.7	-4.2	-4.4	-5.4	-6.1
	-3"	-9.4	-9.4	-9.4	-9.0	-8.4	-8.0	-7.8
	-4"	-9.4	-9.4	-9.4	-9.4	-9.2	-8.9	-8.7
	-6"	-9.3	-9.4	-9.4	-9.4	-9.4	-9.3	-9.2
	Bottom Surface	-9.4	-9.4	-9.4	-9.4	-9.5	-9.2	-9.1

TABLE 15 (Cont'd)

Slab	Time	60	152	175
Air		-8.6	-10.8	-9.6
6"-1" Urethane				
	Top Surface	-7.4	-8.8	-9.0
	-1"	-7.2	-8.6	-8.7
	-3"	-7.9	-8.3	-8.5
	-5"	-8.7	-8.3	-8.4
	-6"	-8.8	-8.3	-8.4
6"-1 1/2" Urethane				
	Top Surface	-7.3	-8.9	-9.0
	-1"	-7.1	-8.6	-8.8
	-3"	-7.9	-8.3	-8.5
	-5"	-8.7	-8.3	-8.4
	-6"	-8.8	-8.3	-8.4
6"-1" Vermiculite				
	Top Surface	-7.1	-8.5	-8.7
	-1"	-6.9	-8.3	-8.5
	-3"	-7.8	-8.1	-8.3
	-5"	-8.5	-8.1	-8.3
	-6"	-8.8	-8.1	-8.3
6"-Uninsulated				
	Top Surface	-6.6	-8.2	-8.2
	-1"	-6.6	-8.0	-8.1
	-3"	-7.4	-7.8	-8.1
	-5"	-8.4	-8.0	-8.2
	Bottom Surface	-8.5	-8.2	-8.3
6"-3/4" Urethane				
	Top Surface	-7.2	-8.7	-8.8
	-1"	-7.2	-8.5	-8.7
	-3"	-7.7	-8.3	-8.4
	-5"	-8.6	-8.2	-8.3
	-6"	-8.7	-8.2	-8.3
7"-Uninsulated				
	Top Surface	-7.0	-8.6	-8.8
	-1"	-6.8	-8.5	-8.7
	-3"	-7.7	-8.3	-8.6
	-4"	-8.5	-8.4	-8.6
	-6"	-9.0	-8.6	-8.7
	Bottom Surface	-9.0	-8.7	-8.7

TABLE 16

TEST VI SLAB TEMPERATURES

Slab	Time	0	9	15	24	35	44	55	68
Air		-9.2	-0.5	2.2	4.4	5.7	7.6	7.9	10.1
6"-1" Urethane									
	Top Surface	-9.2	-8.2	-6.9	-5.9	-5.0	-4.9	-3.8	-3.0
	-1"	-9.1	-9.0	-8.1	-7.4	-6.7	-6.5	-5.7	-5.0
	-3"	-8.9	-9.0	-8.8	-8.5	-8.1	-7.9	-7.5	-7.0
	-5"	-8.8	-9.0	-8.7	-8.7	-8.6	-8.5	-8.2	-7.9
	-6"	-8.8	-8.9	-8.7	-8.7	-8.5	-8.5	-8.2	-7.9
6"-1 1/2" Urethane									
	Top Surface	-9.1	-7.7	-6.3	-5.3	-4.6	-4.3	-3.1	-2.3
	-1"	-9.0	-8.8	-7.8	-7.0	-6.1	-6.0	-5.1	-4.4
	-3"	-8.8	-9.0	-8.8	-8.6	-8.2	-7.9	-7.5	-7.1
	-5"	-8.8	-8.9	-8.9	-8.8	-8.7	-8.4	-8.2	-7.9
	-6"	-8.9	-8.9	-8.9	-8.8	-8.7	-8.5	-8.3	-8.0
6"-1" Vermiculite									
	Top Surface	-8.9	-8.3	-7.5	-6.8	-6.2	-5.8	-5.0	-4.3
	-1"	-8.8	-8.8	-8.3	-7.8	-7.1	-6.9	-6.3	-5.7
	-3"	-8.6	-8.9	-8.8	-8.6	-8.2	-8.0	-7.6	-7.2
	-5"	-8.6	-8.9	-8.7	-8.5	-8.1	-7.9	-7.6	-7.2
	-6"	-8.6	-8.6	-8.3	-8.0	-7.6	-7.5	-7.0	-6.5
6"-Uninsulated									
	Top Surface	-8.8	-8.0	-7.1	-6.5	-5.9	-5.1	-4.1	-3.3
	-1"	-8.8	-8.5	-7.8	-7.2	-6.5	-6.1	-5.2	-4.4
	-3"	-8.7	-9.0	-8.7	-8.3	-7.6	-7.2	-6.6	-5.8
	-5"	-8.7	-8.6	-8.0	-7.4	-6.6	-6.5	-5.5	-4.7
	Bottom Surface	-8.7	-8.0	-7.0	-6.3	-5.8	-5.2	-4.1	-3.3
6"-3/4" Urethane									
	Top Surface	-9.0	-7.9	-6.8	-5.8	-5.4	-4.8	-3.8	-3.0
	-1"	-9.0	-8.8	-8.1	-7.4	-6.7	-6.4	-5.6	-4.9
	-3"	-8.7	-8.9	-8.8	-8.4	-8.0	-7.7	-7.3	-6.8
	-5"	-8.7	-8.9	-8.7	-8.6	-8.4	-8.2	-7.9	-7.5
	-6"	-8.7	-8.8	-8.6	-8.5	-8.4	-8.2	-7.9	-7.5
7"-Uninsulated									
	Top Surface	-9.1	-7.8	-6.8	-5.8	-5.7	-4.8	-3.8	-3.0
	-1"	-9.1	-8.6	-7.8	-7.0	-6.4	-6.1	-5.1	-4.3
	-3"	-9.1	-9.2	-9.0	-8.6	-8.0	-7.6	-7.0	-6.2
	-4"	-9.0	-9.2	-9.0	-8.6	-8.0	-7.6	-6.9	-6.2
	-6"	-9.0	-8.7	-8.0	-7.2	-6.6	-6.2	-5.3	-4.4
	Bottom Surface	-8.9	-7.6	-6.4	-5.5	-5.4	-4.4	-3.3	-2.4

TABLE 16 (Cont'd)

Slab	Time	76	90	97	103	113	124	133
Air		10.8	11.9	12.2	12.6	13.5	14.4	14.7
6"-1" Urethane								
	Top Surface	-2.5	-1.9	-1.6	-1.4	-1.0	-0.7	-0.6
	-1"	-4.6	-4.0	-3.7	-3.3	-3.0	-2.6	-2.3
	-3"	-6.7	-6.1	-5.9	-5.6	-5.2	-4.8	-4.5
	-5"	-7.6	-7.2	-6.9	-6.7	-6.3	-5.9	-5.5
	-6"	-7.6	-7.2	-7.0	-6.7	-6.4	-5.9	-5.6
6"-1 1/2" Urethane								
	Top Surface	-1.9	-1.3	-1.1	-0.8	-0.5	-0.4	-0.3
	-1"	-4.0	-3.3	-3.1	-2.8	-2.5	-2.1	-2.0
	-3"	-6.9	-6.3	-6.1	-5.8	-5.4	-5.0	-4.7
	-5"	-7.7	-7.2	-7.0	-6.7	-6.4	-5.9	-5.6
	-6"	-7.8	-7.3	-7.1	-6.8	-6.5	-6.0	-5.7
6"-1" Vermiculite								
	Top Surface	-4.0	-3.3	-3.0	-2.7	-2.3	-1.8	-1.5
	-1"	-5.3	-4.7	-4.4	-4.1	-3.7	-3.2	-2.9
	-3"	-6.9	-6.3	-6.1	-5.8	-5.5	-4.9	-4.6
	-5"	-6.9	-6.3	-6.1	-5.8	-5.5	-4.9	-4.6
	-6"	-6.2	-5.7	-5.4	-5.1	-4.8	-4.2	-3.9
6"-Uninsulated								
	Top Surface	-2.8	-2.0	-1.5	-1.2	-0.7	-0.3	-0.3
	-1"	-3.8	-3.0	-2.6	-2.2	-1.7	-1.2	-1.0
	-3"	-5.3	-4.4	-4.0	-3.5	-2.9	-2.2	-1.8
	-5"	-4.2	-3.3	-2.8	-2.4	-1.8	-1.1	-0.5
	Bottom Surface	-2.8	-1.9	-1.5	-1.1	-0.6	0.3	1.0
6"-3/4" Urethane								
	Top Surface	-2.6	-1.9	-1.6	-1.2	-1.0	-0.6	-0.5
	-1"	-4.5	-3.8	-3.5	-3.2	-2.8	-2.4	-2.1
	-3"	-6.5	-5.9	-5.7	-5.4	-5.0	-4.5	-4.2
	-5"	-7.3	-6.8	-6.6	-6.3	-5.9	-5.4	-5.1
	-6"	-7.3	-6.8	-6.6	-6.3	-5.9	-5.4	-5.1
7"-Uninsulated								
	Top Surface	-2.5	-1.8	-1.4	-1.1	-0.7	-0.4	-0.3
	-1"	-3.8	-3.1	-2.7	-2.3	-1.9	-1.4	-1.1
	-3"	-5.7	-4.9	-4.5	-4.1	-3.5	-2.8	-2.3
	-4"	-5.7	-4.8	-4.4	-4.0	-3.3	-2.6	-2.1
	-6"	-3.9	-3.0	-2.6	-2.2	-1.5	-0.7	-0.1
	Bottom Surface	-1.9	-1.1	-0.7	-0.3	0.5	1.5	2.0

TABLE 16 (Cont'd)

Slab	Time	152	164	171	181	190	200	206
Air		15.2	16.0	16.2	16.5	16.8	17.2	17.3
6"-1" Urethane								
	Top Surface	-0.5	-0.4	-0.3	-0.3	-0.2	0.2	0.9
	-1"	-2.0	-1.7	-1.6	-1.4	-1.3	-0.9	-0.7
	-3"	-3.8	-3.4	-3.2	-3.0	-2.7	-2.4	-2.2
	-5"	-4.8	-4.3	-4.1	-3.8	-3.5	-3.1	-3.0
	-6"	-4.8	-4.3	-4.1	-3.8	-3.5	-3.1	-3.0
6"-1 1/2" Urethane								
	Top Surface	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	0.0
	-1"	-0.6	-1.4	-1.3	-1.2	-1.1	-1.0	-0.9
	-3"	-4.0	-3.6	-3.4	-3.1	-2.9	-2.6	-2.5
	-5"	-4.9	-4.4	-4.2	-3.9	-3.6	-3.2	-3.1
	-6"	-5.0	-4.5	-4.2	-3.9	-3.6	-3.3	-3.1
6"-1" Vermiculite								
	Top Surface	-0.8	-0.5	-0.4	-0.3	-0.3	-0.2	-0.1
	-1"	-2.1	-1.7	-1.5	-1.3	-1.1	-0.9	-0.8
	-3"	-3.8	-3.2	-2.9	-2.6	-2.2	-1.9	-1.7
	-5"	-3.8	-3.2	-2.9	-2.5	-2.1	-1.7	-1.5
	-6"	-3.0	-2.4	-2.1	-1.7	-1.3	-1.0	-0.7
6"-Uninsulated								
	Top Surface	-0.1	0.0	-0.0	0.0	0.8	2.1	2.6
	-1"	-0.5	-0.2	-0.1	0.0	0.4	1.4	1.8
	-3"	-0.7	-0.1	0.2	0.5	0.9	1.4	1.6
	-5"	0.7	1.5	1.8	2.3	2.8	3.3	3.5
	Bottom Surface	2.2	2.9	3.3	3.8	4.2	4.7	4.9
6"-3/4" Urethane								
	Top Surface	-0.4	-0.3	-0.2	-0.2	-0.2	-0.1	0.1
	-1"	-1.7	-1.4	-1.3	-1.2	-1.1	-0.9	0.7
	-3"	-3.5	-3.1	-2.9	-2.6	-2.4	-2.1	1.9
	-5"	-4.3	-3.8	-3.5	-3.2	-2.9	-2.6	2.4
	-6"	-4.3	-3.8	-3.5	-3.2	-2.9	-2.5	2.3
7"-Uninsulated								
	Top Surface	-0.2	0.0	0.0	0.0	0.0	0.2	2.5
	-1"	-0.7	-0.4	-0.3	-0.2	0.0	0.8	1.4
	-3"	-1.3	-0.8	-0.5	-0.1	0.3	0.7	1.0
	-4"	-0.9	-0.2	0.2	0.6	1.0	1.5	2.8
	-6"	1.1	1.9	2.3	2.8	3.3	3.8	4.1
	Bottom Surface	3.2	4.0	4.4	4.9	5.3	5.8	6.1